NOTICE

All drawings located at the end of the document.

53844

TECHNICAL MEMORANDUM

REVISED FIELD SAMPLING PLAN
AND DATA QUALITY OBJECTIVES

THE WEST SPRAY FIELD (IHSS 168)
OPERABLE UNIT NO. 11

FINAL

ROCKY FLATS PLANT

U. S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

ENVIRONMENTAL RESTORATION MANAGEMENT
March 31, 1994

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EXECUTIVE SUMMARY

This Technical Memorandum (TM) presents the Revised Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) Field Sampling Plan (FSP) and Data Quality Objectives (DQOs) for Operable Unit 11 (OU 11), West Spray Field This FSP refines and focuses the scope of work for the investigation originally presented in the OU 11 Phase I RFI/RI Work Plan (EG&G 1992a) The justification for proposing this revised FSP is based upon 1) A rigorous statistical review of historical data collected for the WSF, 2) recent information obtained from a radiation screening survey and 3) current groundwater monitoring activities Most of this data and analysis was not available during the development of the original OU 11 Work Plan ~~FSP~~

OU 11 is classified as a RCRA lead OU in the Interagency Agreement (IAG) As a result of this classification, OU 11 originally was planned to be investigated in two separate phases These phases are defined in Attachment 2, Section I B 11 b of the IAG During the initial phase, the nature and extent of contamination within the "source and soil" would be investigated In the next phase, the "nature and extent" of contamination that may have the potential to migrate outside the boundaries of the OU would have been investigated This revised FSP proposes to combine both phases of the investigation and subsequent reporting

RCRA Subpart G Part 265 111(b) and the Colorado Hazardous Waste Act (CHWA, 6CCR1007) requires a closure performance standard that "controls, minimizes, or eliminates [contamination] to the extent necessary to protect human health and the environment" Compliance with this requirement is demonstrated by controls that can be established to mitigate any identified risk Typically, this risk assessment process is divided into two separate assessments since the data necessary to determine risk from all potential pathways (i e groundwater, air, etc) is provided by two separate field investigations The Phase I risk assessment evaluates risk from the "upward pathways" (i e exposure by air transport of contaminants or direct contact with contaminants) Phase II would evaluate exposure from contaminated groundwater or surface water

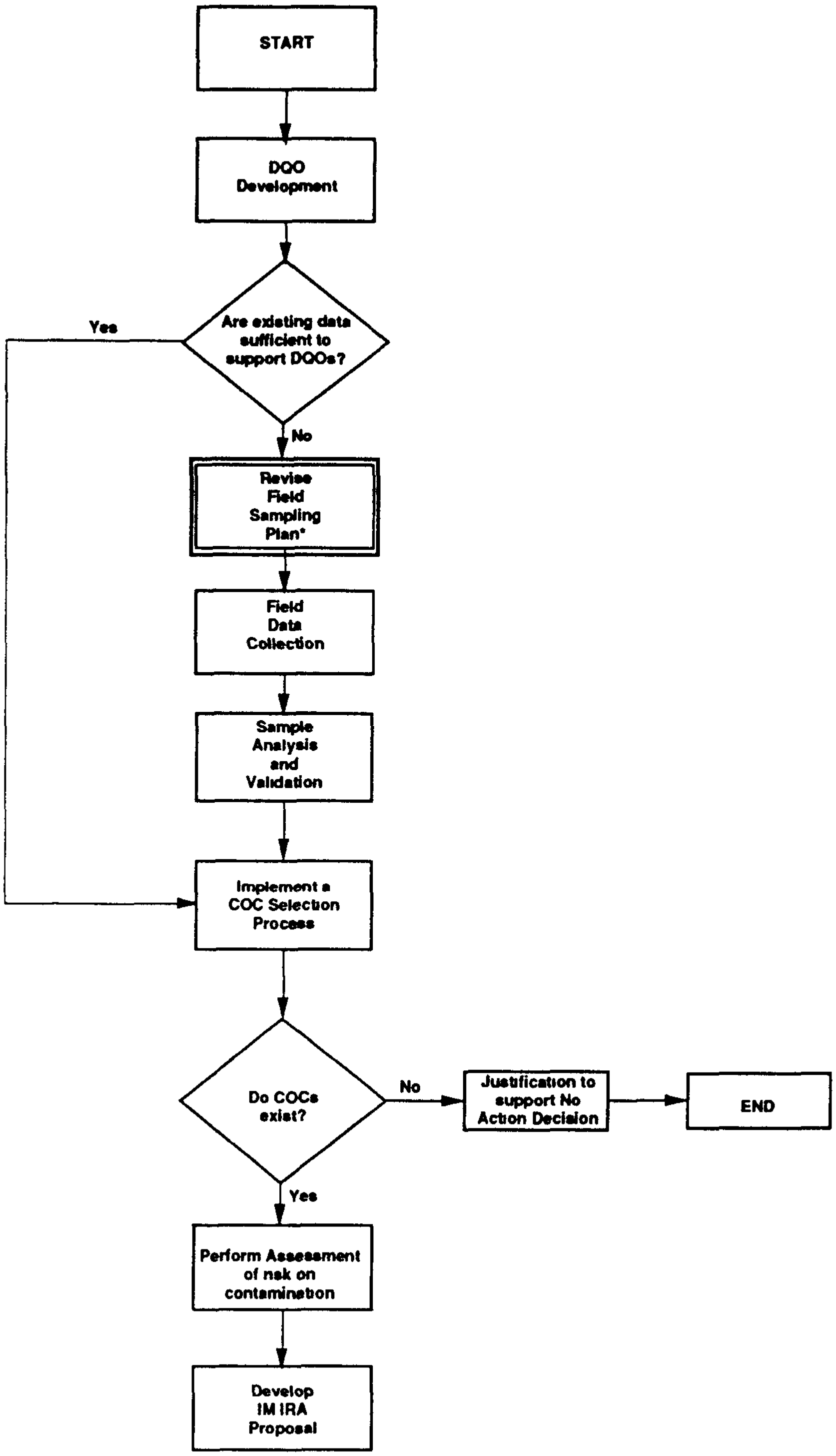
The objective of this revised FSP is to acquire data to determine if potential sources exist within OU 11 that might present a risk to human health or the environment as required However, this revised FSP proposes that activities from the Phase I Investigation be combined with the Phase II investigation activities Combining these phases will allow an early comprehensive assessment of risk and will provide data for public presentation several years ahead of the original IAG schedule The proposed process for investigation and evaluation of risk at OU 11 is represented in Figure ES-1

The fieldwork proposed consists of

- An ecological impact assessment
- A focused High Purity Germanium (HPGe) field screening for potential radiological contamination,
- Vadose zone investigations to assess the nature and extent of potential contamination and to assess the viability of this medium as a contaminant transport pathway and,
- A surficial soil sampling program to verify HPGe results and verify data acquired in historical surficial soil samples

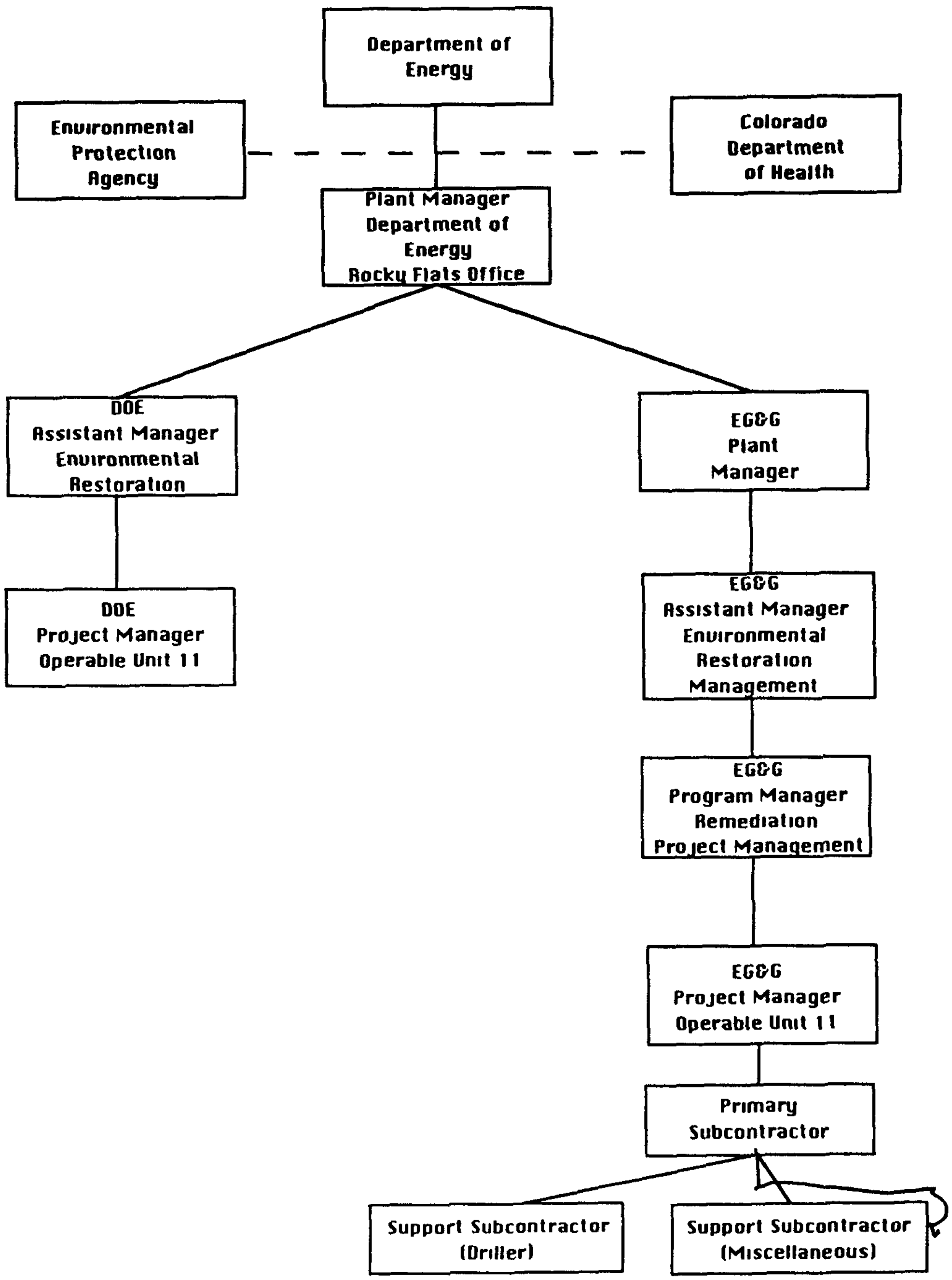
The organizational responsibilities chart for the OU 11 RFI/RI investigation is shown in Figure ES-2

FIGURE ES-1 OU 11 PROCESS FLOW DIAGRAM



*Highlighted box indicates current stage of the OU 11 process

FIGURE ES-2 - OU 11 Organizational Chart



1.0
INTRODUCTION

1 1 PURPOSE AND SCOPE

Purpose

The purpose of this Technical Memorandum (TM) is to provide support for and presentation of a field program that integrates the Phase I and II RFI/RI field investigations for OU 11 The purpose of an RFI/RI field investigation is to determine the risk to human health and the environment, and to define and justify a final action For the WSF, it is believed that the most efficient method to determine risk and the actions necessary to alleviate those risks is to

- streamline the Phase I and II field investigations into a single comprehensive effort, and,
- focus the investigation on those areas and media of the WSF where data is lacking

This approach will eliminate the need for interim studies and investigations, and is based upon a thorough examination of existing data from recent, ongoing, and historical studies (presented in Section 3 of this TM) Historical data would be used to the fullest extent in support of this effort Preliminary and screening data have been gathered to supplement historical data where feasible

Scope

The scope of this TM consists of the following tasks

- establish goals for the FSP (Section 2),
- evaluate existing data to determine where further investigation is necessary (Section 3), and,
- propose a revised scope for the OU 11 field investigation Section 4,

Justification for the revised field investigation is provided throughout Sections 3 and 4

As stated above, the objective of this TM is to evaluate existing field data, to determine the information needed to meet RFI/RI sampling requirements, and to recommend a streamlined approach for completing future field investigations In order to accomplish this objective, Data Quality Objectives (DQOs) will first be outlined in order to establish goals for the FSP DQOs are quantitative and qualitative statements established to ensure that the type, quality and quantity of the data obtained from the investigation are appropriate for the purpose of the project Second, data from preliminary screening and historical investigations will be assessed for its applicability Preliminary screening data includes surficial radiological surveys to determine personal protective equipment levels, and historical data includes all previous investigations at the WSF, including groundwater monitoring, surficial soil sampling, well logs, aerial photos, etc Finally, the FSP will be presented based upon the DQOs and existing data

1 2 BACKGROUND

As part of the Rocky Flats Environmental Restoration program, a multiple-phased RFI/RI is required to investigate the nature and extent of potential contamination at OU 11, the West Spray Field (WSF) Phase I would investigate the nature and extent of contamination within the "source and soils" Phase II would typically investigate "the nature and extent" of contamination from OU 11, which has been interpreted as defining any contamination that may have migrated outside the boundaries of the WSF

The WSF is located on the west side of the Rocky Flats Plant (RFP) and covers an area of approximately 105 1 acres Between April 1982 and October 1985, three areas of the WSF were used for periodic spray application of excess liquids pumped from the Solar Evaporation Ponds 207-B North and 207-B Center Pond 207-B Center was a repository for effluent from the Sewage Treatment Plan (STP) The STP processes sanitary waste from the plant Pond 207-B North was a repository for water from the interceptor trench system (ITS) The ITS was installed to collect groundwater and seepage from the hillside north of the Solar Evaporation Ponds and water from the Building 771 and 774 footing drains

The approximate combined spray area for all three lines was 41 3 acres Area 1 was approximately 35 6 acres in size and accommodated three fixed spray lines (two were previously portable lines) with a width of 80 feet and an average length of 1,524 feet Area 2 covered approximately 2 5 acres and accommodated a single fixed irrigation line A spray impulse cannon with a maximum spray radius of 100 feet was used on an east-west trend in Area 3 (3 2 acres) Figure 1-1 illustrates the three areas of spray application

Total volumes of Solar Pond water applied between April 1982 and October 1985, and the estimated areas of application for Areas 1, 2, and 3, were used to estimate the amount of water applied from each source It is estimated that 40 inches of water from Pond 207-B North was applied in Area 1, and 150 inches of water from Pond 207-B Center was applied in Areas 1, 2, and 3 Because liquids from both ponds were applied to Area 1, the <u>maximum</u> total application could have been as much as 190 inches over the 8 4 acre area for all four years of application (approximately 66,000,000 gallons)

2.0
DATA QUALITY OBJECTIVES

The U S Environmental Protection Agency (EPA) has established a 7-step process to SUPERFUND decision-making as the basis for developing DQOs (EPA, 1993a) DQOs are quantitative and qualitative statements that are established to ensure that the type, quality and quantity of the data are optimized for accomplishing the purpose of the project DQOs, Looks funny?

1 clarify the study objective,
2 define the most appropriate type of data to collect,
3 determine the most appropriate conditions from which to collect the data, and,
4 specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support the decision (EPA, 1993a)

For the OU 11 project, the intended use of the data includes human health and ecological risk assessment Analytical results will be compared with background RFP values, risk-based calculations, and Applicable or Relevant and Appropriate Requirements (ARARs) If required, the data will also be the basis for corrective measure design In addition, precision, accuracy, representativeness, comparability, and completeness (PARCC) are DQOs set forth in the EPA Guidelines (EPA, 1987), DOE Data Management Requirements (DOE, 1993), and the Quality Assurance Project Plan (QAPjP) (EG&G, 1992b)

2 1 Data Quality Objectives Process

The DQO process is a series of planning steps based on the scientific method that is designed to ensure that the type, quantity, and quality of environmental data used in decision making are appropriate for the intended application (EPA, 1993a) The DQOs are statements derived from an iterative 7-step process that streamlines the study so that only those data needed to make a decision are collected and used The process consists of the following seven steps

1. State the Problem
2. Identify the Decision
3. Identify Inputs to the Decision
4. Define the Study Boundaries
5. Develop a Decision Rule
6. Specify Limits on Decision Errors
7. Optimize the Design for Obtaining Data

Step 1 State the Problem

The WSF at the RFP has been exposed to waters originating from the ITS and the Solar Evaporation Ponds and, with process knowledge, the risk to human health and the environment is unknown and must be determined Possible contamination is from radionuclides, metals, and major anions A hydrogeologic conceptual site model was developed for the OU and is presented in detail in this section Due to the lack of data concerning groundwater in the upper portion of the upper hydrostratigraphic unit (Figure 2-1), this media will be the primary concern of the OU 11 investigation presented in this FSP

Several types of environmental specialists are needed to implement the DQO process The planning team consists of a project manager and lead, a hydrogeologist, two statisticians, at least three risk assessors, a geologic engineer, quality assurance personnel, and two biologists The primary decision makers consist of representatives from the Colorado Department of Health (CDH), EPA, DOE and EG&G Project Management for OU 11

Conceptual Site Model

The function of the WSF conceptual model is to describe the site and its environs and to present hypotheses regarding contamination (or potential contamination), routes of migration, and potential impact on receptors The original Phase I RFI/RI Work Plan for OU 11 presented a conceptual model that included a description of the contaminant source, release mechanisms, transport medium, contaminant migration pathways, exposure routes, and receptors The Hydrogeologic Conceptual Model (Figure 2-1) takes the modeling process one step further by presenting potential migration pathways in a geologic setting The primary release mechanisms for contaminants from the WSF are fugitive dust, surface-water runoff, infiltration and percolation of groundwater, bioconcentration/bioaccumulation, and tracking The possible exposure pathways for contaminants resulting from spray application include ingestion, inhalation, and dermal contact of the contaminated soil, groundwater, and/or surface water

Surficial and shallow soils, which received waste water through direct application and surface runoff, are recognized as the primary media of concern for potential contamination However, historical analytical results show most contaminant concentrations in these media are below background levels (Section 3 3) Soil characterization activities and recommendations relative to previously collected data are presented in Sections 3 0 (Summary of Existing Data) and 4 0 (Sampling and Analysis Plan) of this TM

The upper portion of the upper hydrostratigraphic unit has not been thoroughly investigated The media of concern that received the most attention historically were shallow soils, surface soils, and the saturated zone (the lower portion of the upper hydrostratigraphic unit) Relatively little attention has been given to potential perched water zones resulting from spray application This perched system is thought to exist for two reasons,

1 Continuously screened wells (those screened through the entire upper hydrostratigraphic unit) generally show higher levels of particular contaminants than those screened only in the lower portion of the upper hydrostratigraphic unit

2 Shallow water zones were encountered during past drilling operations

Perched water zones would have a greater potential of retaining contamination than the lower portion of the upper hydrostratigraphic unit due to the proximity of spraying operations Therefore, the potential for a perched water system to exist and accumulate contaminants will be investigated

Hydrogeologic Conceptual Model

The primary goal of the FSP is to evaluate the potential of risk from current contamination levels Previous soil and groundwater investigations do not indicate that significant levels of contamination exist in OU 11 (Appendix C) Data collected from wells constructed to evaluate only the saturated zone of the uppermost hydrostratigraphic unit indicate that concentrations for individual contaminants are insignificant However, elevated levels of some contaminants, specifically nitrates, have been detected in wells which were screened to evaluate the entire (saturated and unsaturated) uppermost hydrostratigraphic unit at OU 11 (Figure 2-2) It is hypothesized that these elevated levels are the result of the contribution of contaminated perched groundwater mounds to the overall shallow groundwater system (evidence for perched groundwater conditions is further discussed in Section 4 5) To date, characterization of shallow subsurface lithologies and water chemistries is incomplete

At the WSF, the uppermost hydrostratigraphic unit is the Rocky Flats Alluvium (RFA), a heterogeneous alluvial fan deposit consisting of unconsolidated gravels, sands, and clays with the water table at a depth of approximately 50 feet As previously discussed, the probable existence of perched water in the vadose zone is of primary concern for potential groundwater contamination

The following is a conceptual model for shallow groundwater mounding, which is proposed as a hypothesis to be evaluated Spray application of water occurred during several years as a waste management activity Surface runoff, evapotranspiration, and infiltration occurred during that time, and infiltrated water recharged the alluvial hydrostratigraphic unit to a small extent In addition, water may have accumulated over semi-pervious clay layers or lenses of lower vertical hydraulic conductivity Finally, when spraying ceased, the amount of water that was perched began to diminish due to continued downward migration and evapotranspiration If contaminants were present, they may still exist in these perched zones either as dissolved constituents or precipitates

As explained above, historical water level data and recent drilling reports indicate that perched water conditions probably exist under portions of OU 11 Evidence for perched conditions is discussed in detail Section 4 5 where justification of monitoring well locations is also presented If groundwater has become contaminated to significant levels above background because of spray application, perched water, by virtue of its proximity to the surface of application, would have the potential for containing maximum elevated levels of contamination The migration of contaminated perched groundwater ~~would~~ could constitute a potential health risk To date, the characterization of vadose zone geology and water chemistry is incomplete As previously mentioned, most monitoring wells in the WSF were designed to monitor the saturated zone of the uppermost hydrostratigraphic unit In addition, because of the presence of large cobbles and boulders in the alluvial gravels, most of these wells were drilled using percussion technology Lithologic descriptions of the collected cuttings lack accuracy and detail Therefore, for this investigation, subsurface lithologies, as well as borehole and groundwater chemistries will be characterized (in accordance with Section 4 6, Analytical Requirements) Seismic data were not utilized for the selection of the drill sites However lithologic data collected from the FSP will be used as an aid in calibrating the seismic data to the subsurface geology

Mathematical Modeling of Perched Groundwater Mounds

For preliminary planning purposes, mathematical analytical modeling was performed Using a method documented by Brock (Brock, 1976), a hypothetical two dimensional mound profile under WSF Area 1 was developed Appendix B shows the model calculations used to predict mound height and extent Parameters used in the model were in accordance with field data collected in other areas of RFP and professional judgement Hydrologic assumptions relevant to the model are similar to those inherent in various groundwater models and are explicitly stated This model was specifically used to provide a rough "order-of-magnitude" analysis of anticipated perched groundwater mound height Modeling results suggest that perched mounds resulting from spray application would be relatively thin, with the calculated steady state mound height under Spray Area 1 being approximately seven feet

Step 2 Identify the Decision

The Decision

A decision will be made as to whether the concentrations of the potential contaminants of concern are a risk to human health and the environment The analytical data that exceed background concentrations, ARARs, or Preliminary Remediation Goals (PRGs), will warrant further assessment and/or a response action

Actions as a result of the resolution of the decision.

A decision of no action is required if Potential Contaminant of Concern (PCOCs) for each medium individually do not exceed background values, ARARs or PRGs Further assessment and/or a response action will be conducted if action levels are exceeded For example, if levels of contamination are found that exceed threshold values, then further vadose zone characterization will be considered for analysis of the migration of contaminated groundwater as a source of significant risk If no perched water mounds are found or if levels of contamination are found below threshold values in shallow perched groundwater mounds, then no further characterization of the groundwater system will be deemed necessary

Step 3 Identify the Inputs to the Decision

Information that will be required to make the decision.

All historical analytical data collected from the 1988 test pits sampling, historical and current monitoring well activities, and process knowledge of the Solar Evaporation Ponds (quantitative and qualitative) will be compiled to identify the areal extent of contamination in order to determine the sample variance and sample mean of analytes from each media sampled over time at the WSF

To assess risk, this investigation will also include the examination of

- Groundwater flowpaths and hydraulic gradients of the upper aquifer
- Water levels, potentiometric surface, hydraulic gradient and potential clay lenses from previously installed wells
- Hydrological modeling input and out-put data to further identify the presence and extent of the perched water mounds that are indicative of the site

Information needed to identify the action level.

The action levels of the PCOCs will be determined by the regulatory agencies and will include consideration of background values, ARARs and PRGs

The appropriate sampling techniques and analytical methods used to obtain the data.

EPA-approved field sampling techniques for sub-surface soil sampling, monitoring well installation, and groundwater sampling are listed in Section 4 5 of this TM The associated analytical parameters that will be used for the sampling are listed in Section 4 6 of this TM The analytical methods for each parameter are listed in Appendix B of the QAPjP (EG&G, 1992b) Table 2-1 summarizes the objectives, activities, uses, and analytical levels for this investigation

Table 2-1

OBJECTIVES AND ACTIVITIES OF THE REVISED FIELD SAMPLING PLAN

Objective	Activity	Data Type	Data Use
Determine if Contamination Exists in the Vadose Zone	1) Collect and analyze soil samples from borehole core 2) Install monitoring wells to collect and analyze perched groundwater 3) Determine total drilling depth with the use of a field moisture measuring instrument	FIELD QUANTITATIVE FIELD QUANTITATIVE FIELD	Site characterization Risk assessment Field Decisions
Determine if Contamination Exists in Surface Soils	1) Obtain recent HPGe Survey data & evaluate against 1989 aerial survey 2) Collect and analyze Surface Soil Samples	QUANTITATIVE FIELD QUANTITATIVE	Site characterization Risk assessment Health and Safety
Assess Current Ecological Conditions	1) Compare current conditions to background 2) Determine the absence or presence of adverse impacts to the ecology	QUANTITATIVE FIELD QUANTITATIVE	Site characterization Risk assessment

Step 4 Boundaries

Spatial boundaries.

The investigation of OU 11 (IHSS 168) will focus on surface soils, sub-surface soils, and groundwater from perched groundwater mounds Sub-surface soil sampling will extend to the saturated zone and samples will be collected at two foot intervals (the upper five feet of the vadose zone is of particular interest) Groundwater will be sampled from monitoring wells [illegible] ~~installed~~ in the boreholes

Characteristics that will define the population of interest.

The PCOCs for the baseline risk assessment, which are yet to be determined, will focus on surface soils, sub-surface soils, and groundwater The data collected will be compared to the established background analyte levels, relevant ARARs and PRGs

The scale of decision making.

Samples will be collected from surficial soils, subsurface soils (soil boreholes), and perched water mounds Separate decisions will be made for surface soils, each identified perched water mound, and the associated sub-surface soil and clay layers

Temporal boundaries.

In 1986 and 1988, soils studies showed that surface soils in the WSF do not pose an immediate threat to human health or the environment Similarly, no threat is indicated from RCRA groundwater monitoring, which has been conducted since 1988 Field work ~~However, further investigation~~ of OU 11 will begin as soon as the the FSP is approved and expected to be approximately 1 January ~~regulatory agencies approve the revised FSP~~ Since the FSP combines the Phase I and Phase II programs for OU 11, the activities will be tightly focused, and an RFI/RI report will be completed several years ahead of the original IAG schedule

Practical constraints on the data collection.

The most important possible constraint on data collection is the ability to penetrate the RFA for thorough sample collection Because the RFA is heterogeneous alluvial material, standard drilling methods have proven inadequate for sample collection Use of a sonic drilling rig is proposed for future work, as it has worked well for other investigations in similar geologic materials

Step 5 Develop a Decision Rule

Parameters that characterize the population of interest.

PCOC concentrations will be specified as a characteristic or attribute with regards to minimum, maximum, mean, and/or as a variance that is relevant for each of the sampled media that will be compared to the pertinent threshold value

Action levels for the study.

The action levels for OU 11 will be the validated value ± 20%, not exceeding the threshold value The threshold value (i e risk-based values, ARARs, etc) will be determined during the risk assessment portion of the OU 11 RFI/RI

The decision rule for each population of interest.

If the levels of contamination for each environmental media investigated are above threshold levels for the specific contaminants, then the media will be evaluated for further investigation and possible remediation

Step 6 Specify Limits on Decision Errors

Contamination above regulatory concern exists within areas having the highest probability of contamination based on historical spraying and geological conditions For a Type I Error (false positive), the null hypothesis is rejected by mistake, which is to say that there is actually no significant difference between background levels of contamination and OU 11 levels of contamination, but the data show that there is difference in the levels For a Type II error (false negative), the opposite is true, there is a significant difference between background levels of contamination and levels of contamination at OU 11, but the data show that there is no difference The field sampling plan design, proposed in Section 4 0 of this TM, takes historical spraying information and geological conditions into consideration, and makes every attempt to ensure that the sampling program is the most beneficial for error reduction for surface and subsurface soil sampling and groundwater monitoring

Step 7 Optimize the Design

Each media has a sampling plan designed to reduce decisions errors as much as possible For surface soil sampling, a biased approach based upon areas of highest spray and possible runoff is utilized and is presented in Section 4 3 For subsurface soils and groundwater, error is reduced by using data from previously installed wells in order to determine likely locations of perched water (logic for this assumption is presented in Section 4 0) Constituents for investigation are determined based on past investigations at the WSF, current groundwater monitoring data, and Solar Pond water process knowledge

2 2 Establishing the PARCC Parameters

The DQO process takes into account the validation of the sampling effort that is used to identify contaminants of concern (COCs) The process of collecting data and analyzing it to obtain usable, quality data that is defensible with respect to the actions taken at a site are based upon the PARCC of the data These primary analytical DQOs will be used to ensure that the data collected at OU 11 depicts the contaminant levels and the environmental conditions at the time of sampling Details on the calculations pertaining to PARCC Are provided in Section 5.

provided in Section 5

Precision

Analytical precision is expressed as a percentage of the difference between the results of duplicate samples for a given compound The Relative Percent Difference (RPD) for water samples will be ≤ 30% and for soils will be ≤ 40% The overall required percentage of samples to fall within the DQOs stated, per media and analytical suite, is ≥ 85% ~~Details are~~

Accuracy

Accuracy will be expressed in terms of completeness and bias Accuracy is a quantitative measure of data quality that refers to the degree of difference between measured or calculated values and the true value The closer to the true value, the more accurate the measurement One of the measures of analytical accuracy is expressed as a percent recovery of a spike or tracer that has been added to the environmental sample at a known concentration before analysis (EG&G, 1991) Although it is not feasible to totally eliminate sources of error that may reduce accuracy, error will be minimized by using standardized analytical methods and field procedures

These should actually be restated here!!

In addition, the accuracy of each instrument used that ultimately influences project decisions will be stated The correct resolution of reported results, and corresponding number of significant figures will be determined, and all of the corresponding measurements (or calculation results, e g , numerical model output) will be reported consistently This determination will be based on detection limits, for example, from General Radiochemistry and Routine Analytical Protocol (GRRASP) (EG&G, 1990) specifications, manufacturer's specifications, standard operating procedures, and or instrument-specific calibration data

<u>Representativeness</u>

Representativeness will be maximized by ensuring that sampling point locations are selected properly, potential "Hot Spots" are addressed, and a sufficient number of samples are collected over a specified time span All sampling will be conducted as outlined per this FSP and RFP Standard Operating Procedures (SOPs)

<u>Completeness</u>

The amount of usable data collected from the sampling program for all media will be calculated to ensure that the program meets the performance objectives for the study The goal for completeness is 100% with a minimum acceptance of 90%

<u>Comparability</u>

Sample data will be comparable with other measurements for similar samples (matrix types) and conditions The goal for comparability will be achieved by implementing sampling techniques and analytical methods outlined in the SOPs and reporting the results in appropriate units Comparability will only be performed with confidence when precision and accuracy are known and will be performed with respect to one or more of the following

1) protocols (e g , SOPs) used to collect and/or synthesize the samples
2) matrix types (e g , dry soil samples may not be comparable to saturated soil samples

for "fate and transport" purposes)

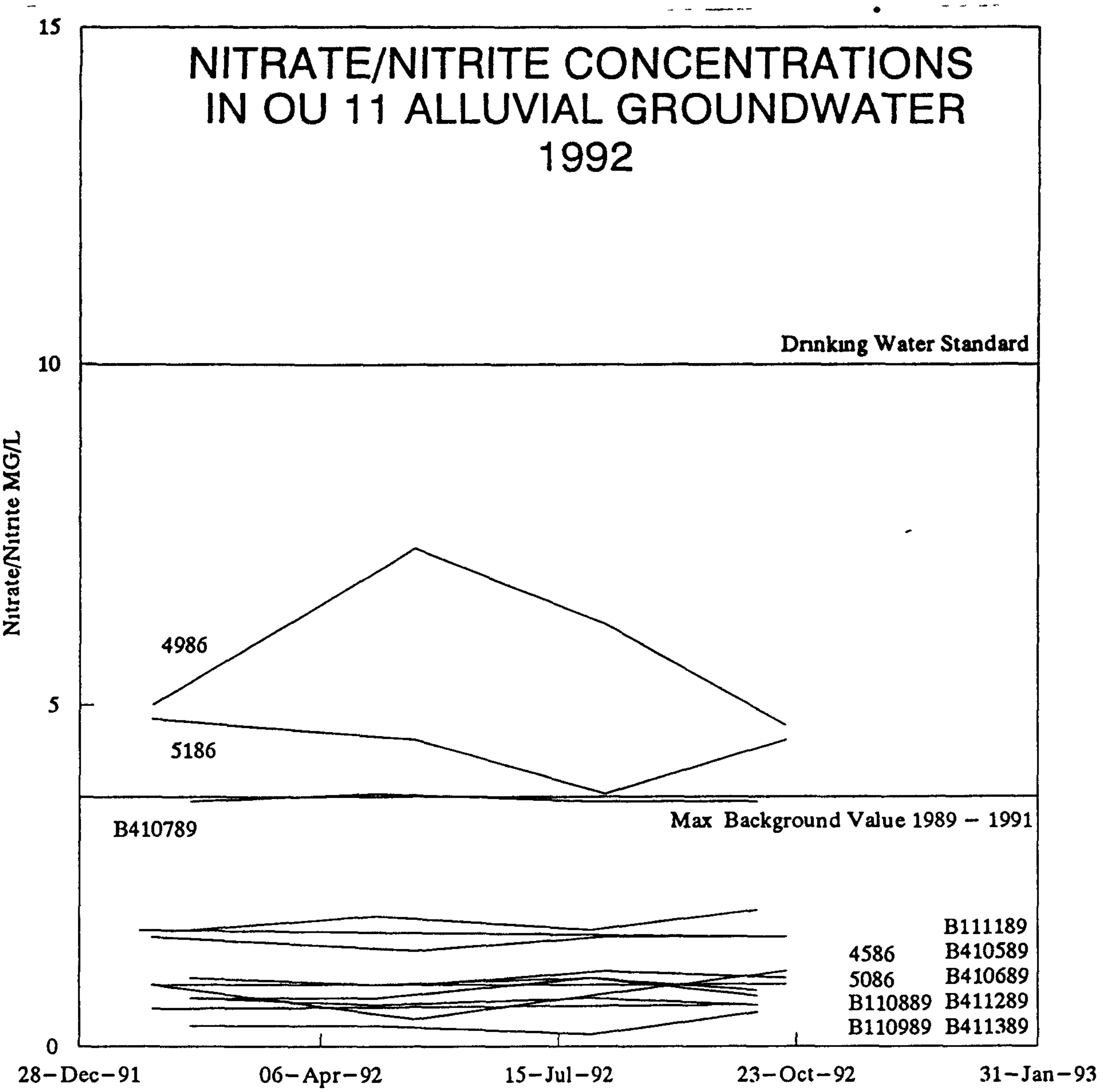
3) temporal considerations (periodical, seasonal, event-related, etc)

4) spatial considerations (3-dimensional)

Data set comparison will (at least) include the comparison of real samples with

1) other real samples, as appropriate, and,

2) background data



Note Wells 4986 and 5186 are screened the length of the well, other wells are screened at the bottom of the alluvium

FIGURE 2–2

OU 11
HYDROLOGIC DATA

TECHNICAL MEMORANDUM
Revised Field Sampling Plan

3 1 OBJECTIVES AND APPROACH

The purpose of this section is to provide a summary review of the data from historical studies, screening activities, and ongoing monitoring at the WSF ~~This historical information is the basis for the revised FSP presented in Section 4 of this TM.~~

A statistical summary of existing analytical data as compared to background data from the Geochemical Characterization Report (EG&G, 1992c) is presented in Appendix C Figure 3-1 shows background and OU 11 sample locations The data sets for OU 11 were QA tested to delete duplicate or rejected data points so that statistical comparisons to background data could be performed

Historical data include analyses from surface water, groundwater, surficial soils and subsurface materials (Figure 3-1) Data from ecological field sampling (performed in the fall of 1993) is also presented Surface water data were gathered through the Rocky Flats Surface-Water Monitoring Network Groundwater data were collected from the RCRA groundwater monitoring program at the plant Data from surficial soils and subsurface materials were obtained from a 1988 test pit study and recent HPGe screening activities The existing soils and groundwater data have been evaluated to provide justification for re-focusing the investigation in the following areas

- reducing and focusing the extensive surficial soil sampling program proposed in the original OU 11 Work Plan (EG&G, 1992a),
- identifying additional data requirements from subsurface materials, and,
- completing a groundwater monitoring network at the WSF with wells screened through shallow intervals of the RFA

Risk from the historical spray application activities at the WSF will be determined by evaluating the additional data proposed and combining it with appropriate historical, ongoing, and screening data

3 2 ECOLOGICAL FIELD SAMPLING

Objectives and Approach

The assessment of the ecological effects and ecological risks associated with the WSF resulting from RFP activities follows EPA guidance (EPA, 1992) As part of that guidance, data acquisition, verification, and monitoring occur interactively with problem formulation, analysis (characterization of exposure and ecological effects), and risk characterization The existing ecological data relevant to OU 11 are described below and will be used in problem formulation Pending the results of the problem formulation, possible future sampling activities are described in section 4 0 All ecological sampling followed Environmental Management Division (EMD) Operating Procedures Manual No 5-21000-OPS-EE Volume V Ecology Specific SOPs are referenced appropriately and listed below

EE 02	Sampling of Macroinvertebrates
EE 05	Sampling of Large Mammals
EE 06	Sampling of Small Mammals
EE 07	Sampling of Birds
EE 09	Sampling of Terrestrial Arthropods
EE 10	Sampling of Vegetation

Status of Ecological Field Sampling

The status of previous field sampling activities for the OU 11 Ecological Evaluation (EE) are summarized in two tables Table D-1 summarizes field sampling activities, both completed and proposed, in direct support of the EE for OU 11 Table D-2 summarizes the extensive sampling done under the EG&G Ecological Monitoring Program (EcMP) which may be relevant and applicable to the EE for OU 11 Given the scarcity of ecological impacts associated with Rocky Flats Plant activities, the EcMP evaluated several of its sampling and analysis methods at OU 11 Many of the EcMP endpoints should be very sensitive to the effects of the addition of water and nitrate to the terrestrial ecosystem Sampling at OU 11 provided the mutually beneficial opportunity to evaluate EcMP methods and add to the state of the art ecological evaluation at this OU

Terrestrial Ecosystems (Sampling in direct support of the OU 11 EE)

Samples were collected from sprayed areas, non-sprayed areas and reference areas Within those areas five meter by five meter grids were sampled for vegetation, small mammals and insects (Table D-1) Vegetation sampling included cover transects, belt transects and production quadrants following SOP EE 10 Terrestrial arthropods were collected by sweep netting in all grids of each area following SOP EE 09 Samples are in secure storage awaiting possible identification and enumeration as indicated by the problem formulation One bird transect, which included portions in both affected and reference areas, was also inventoried following SOP EE 07

Four grids per area were trapped for small mammals following SOP EE 06 In order to expand the relevance of the small mammal data collected, trapping was done for three nights so that results would be comparable with extensive reference data collected under the EcMP The small mammals collected included deer mice (Peromyscus maniculatus) and meadow voles (Microtus pennsylanicus) Large mammals were recorded during performance of relative abundance transects following SOP EE 05 The large mammals observed included coyote (Canis latrans), mule deer (Odocoileus hemionus) and desert cottontail (Sylvilagus auduboni)

Vegetation tissue samples were collected by quadrant from all grids within each area following SOP EE 10 Samples of selected species (Poa compressa, Artemesia ludoviciana, Ambrosia psylostachya, and Andropogon gerardii) are in storage in Building T891G at the RFP in a locked room, in custody sealed boxes, in paper bags, holding the dried vegetation at room temperature Tissue samples await possible analysis as indicated by the problem formulation

Aquatic Ecosystems (Sampling in direct support of the OU 11 EE)

The only permanent surface water monitoring station with a potential aquatic receptor ecosystem directly down gradient from OU 11 is SW-128 This impoundment principally receives runoff from parking lots and may only be influenced by OU 11 during runoff events One qualitative benthic macroinvertebrate sample was collected following SOP EE 02 from each, SW-128 and Lindsay Pond The samples contained a diverse array of 17 and 29 species respectively

The following preliminary data have been collected or formulated as a result of sample collection in direct support of the OU 11 EE

- Small Mammal Capture Data
- Vegetation Production Summaries and Calculations
- Vegetation Production Plot Summary Forms
- Vegetation Cover Summaries and Calculations
- Vegetation Cover Transect Summary Forms
- Vegetation Belt Transect Summaries and Calculations
- Vegetation Belt Transect Summary Forms
- Bird Transect Summaries and Calculations
- Relative Abundance Survey Summary
- Species List of Macrobenthic Organisms

Terrestrial Ecosystems (Sampling by the EcMP in support of the OU 11 EE)

The EcMP is a DOE-mandated program to determine long-term ecological endpoints, exposure values and effects at the RFP (DOE Order 5400 1, DOE Order 5440 1E, 43 CFR Part 11, 40 CFR Part 300 Subparts E&G, and 10 CFR Part 384) This program began field operations in 1993, focusing on the testing of methodologies, experimental designs, sample scheduling, and program operations, all of which had been approved by DOE RFO Soil sampling in OU 11 was conducted in September of 1993 The program had initially been divided into five modules

- Aquatic ecology,
- Terrestrial vegetation, including cover, richness, density, production and litter biomass values and tissue analysis,
- Ecosystem Functions, including background soil physical/chemical measurements, and microbial carbon and nitrogen pools and potential rates of carbon and nitrogen transformations,
- Soil invertebrate analysis, and
- Small mammal population dynamics

Many of the ecological endpoints used in the EcMP are still in a state of development for adaptation to monitoring functions, but the endpoints chosen so far have been reviewed by an independent team of western university research experts (Rocky Mountain Universities Consortium, Denver Research Institute, University of Denver) and DOE's ecological consultant (Dr Beverly Ausmus-Ramses) There is consensus that "best available technology" is being used In particular, ecosystem function measurements, soil invertebrate analysis, and plant tissue analysis on a cover class basis (as opposed to a species basis) have either not been conducted at the RFP or have been in a very different context than current EcMP needs dictate Therefore, the testing of methodologies and designs referred to above was critical to the future of the program Much of the 1993 EcMP sampling took place in the Buffer Zone to define ecological attributes of reference areas EcMP personnel recognized that the nitrogen treatment in the OU 11 area provided a unique opportunity to examine the feasibility and sensitivity of many program variables Since many ecological measurements are affected by both carbon and nitrogen flows and pools, if impacts are indeed detectable, we would expect to find them in an area of heavy nitrogen application (OU 11) Therefore, several EcMP measurements were taken in OU 11 Data that are currently available are being analyzed by EcMP personnel to support monitoring activities, but may be used to supplement the OU 11 Environmental Evaluation These activities are described in more detail in this section The procedures followed are those of the EcMP Soil functional, physical, chemical and invertebrate sampling methods are as documented by the EcMP Vegetation sampling methods used by EcMP are being incorporated into the revised SOP EE 10

Soil samples could not be collected before radiological screening data were available for review by RFP Radiological Engineering Department Screening samples were collected from the 0-10 cm depth, the same depth that all soil samples were taken Five samples for radiological screening analysis were taken, each sample was a composite with soil from five locations Samples were taken from five north-south oriented strips that encompassed the entire OU 11 area Samples were delivered that same day to the RFP Building 881 laboratory and analyzed for gross alpha-beta activities Results indicated total activities (alpha + beta) ranged from 52 to 76 pCi/g

Soil sampling purposefully followed the same approach of vegetation sampling so that these data will be comparable (Table D-2) Figure 3-2 illustrates that five plots (P1-P5), in each of the four sampling sites, in each of the three treatments (sprayed, nonsprayed, and reference areas) were sampled, for a total of 60 sample units Twelve additional QA/QC samples were taken for ecosystem function and invertebrate samples Functional and physical/chemical samples were taken from 0-10 cm depth Soil invertebrate samples were taken from 0-5 and 5-10 cm depths All samples were taken with hand tools (shovels, trowels, knives) and transferred to pre-labeled ziplock plastic bags, which also had labels inside the bags Samples were then placed on blue ice in coolers, sealed, and transferred to a locked room in RFP Building T891 G at the end of the day Samples were logged onto chain-of custody sheets the same day of sampling or the next morning Samples were delivered to laboratories within 48 hours, because of the relatively short holding time of the soil functional samples

Vegetation was collected, dried and weighed by species by plot Litter was dried and weighed by plot Subsets of plant tissue were composited after drying (species basis) by plot for nutrient analysis, it was determined that species nutrient data would be less useful information than average above-ground nutrient data on an area basis Analysis was apportioned as follows 3 (of 5) plots x 2 (of 4) sites x 3 treatments = 18 sample units Subsets of litter (corresponding to plant tissue) were analyzed for the same nutrient elements as plant tissue, with the exception that lignin analysis was performed on all litter samples

Soil sampling was divided into three different areas 1) functional samples, 2) soil invertebrate samples, and 3) physical/chemical properties The following lists the analytes for each area

Soil functional samples

- extractable soil nitrate (NO_3)
- extractable soil ammonium (NH_4)
- total soil nitrogen
- soil particulate organic matter
- microbial nitrogen concentration (direct extraction)
- microbial carbon concentration (direct extraction)
- potentially mineralizable nitrogen (10 day incubation at field capacity moisture and 25^0 C followed by NO_3 and NH_4 analysis)
- potentially respirable carbon (CO_2 analysis following a 10 day incubation at field

capacity moisture and 25^{0} C)

- nitrogen fixation rate
- denitrification rate

Soil Invertebrate Samples

- soil arthropod analysis performed on all samples (identification and enumeration)
- soil nematode analysis performed on all samples (identification and enumeration)
- soil mycorrhyzal analysis performed on a subset of samples (presence/absence and inoculation potential)

Soil Physical/chemical properties

- particle size very coarse sand
- particle size coarse sand
- particle size medium sand
- particle size fine sand
- particle size very fine sand
- particle size total sand
- particle size total silt
- particle size total clay
- soil field water content
- soil water content (0 MPa)
- soil water content (010 MPa)
- soil water content (033 MPa)
- soil water content (5 MPa)
- soil water content (1 5 MPa)
- soil pH, saturated paste, measure suspension
- total soil carbon, CHN analyzer
- soil hydrogen (H), CHN analyzer
- total soil nitrogen (N), CHN analyzer
- soil available phosphorus (P), sodium bicarbonate extract
- soil available potassium (K), sodium bicarbonate extract
- extractable soil iron (Fe), DTPA extract

- extractable soil manganese(Mn), DTPA extract
- extractable soil copper (Cu), DTPA extract
- extractable soil zinc (Zn), DTPA extract
- extractable soil sodium (Na), ammonium acetate extract
- extractable soil potassium (K), ammonium acetate extract
- extractable soil calcium (Ca), ammonium acetate extract
- extractable soil magnesium (Mg), ammonium acetate extract
- extractable soil sulfate (SO_4), HCl extract
- soil cation exchange capacity (CEC), ammonium acetate extract
- soil soluble sodium (Na), water extract
- soil soluble potassium (K), water extract
- soil soluble calcium (Ca), water extract
- soil soluble magnesium (Mg), water extract
- soil digest aluminum (Al), nitric acid digest, EPA method 3050
- soil digest barium (Ba), nitric acid digest, EPA method 3050
- soil digest beryllium (Be), nitric acid digest, EPA method 3050
- soil digest cadmium (Cd), nitric acid digest, EPA method 3050
- soil digest calcium (Ca), nitric acid digest, EPA method 3050
- soil digest chromium (Cr), nitric acid digest, EPA method 3050
- soil digest cobalt (Co), nitric acid digest, EPA method 3050
- soil digest copper (Cu), nitric acid digest, EPA method 3050
- soil digest iron (Fe), nitric acid digest, EPA method 3050
- soil digest lead (Pb), nitric acid digest, EPA method 3050
- soil digest magnesium (Mg), nitric acid digest, EPA method 3050
- soil digest manganese (Mn), nitric acid digest, EPA method 3050
- soil digest molybdenum (Mo), nitric acid digest, EPA method 3050
- soil digest nickel (Ni), nitric acid digest, EPA method 3050
- soil digest phosphorus (P), nitric acid digest, EPA method 3050
- soil digest potassium (K), nitric acid digest, EPA method 3050
- soil digest (Na), nitric acid digest, EPA method 3050
- soil digest sulfur (S), nitric acid digest, EPA method 3050

- soil digest zinc (Zn), nitric acid digest, EPA method 3050
- soil bicarbonate (HCO_3), saturated extract, titration
- soil carbonate (CO_3), saturated extract, titration

Plant and litter tissue were analyzed for the following elements

- plant ash
- aluminum (Al)
- cadmium (Cd)
- calcium
- chromium (Cr)
- copper (Cu)
- iron (Fe)
- lead (Pb)
- magnesium
- manganese (Mn)
- molybdenum (Mo)
- phosphorus
- potassium
- sodium (Na)
- sulfur
- zinc (Zn)

Aquatic Ecosystems (Sampling by the EcMP in support of the OU 11 EE)

As part of the EcMP initial field sampling effort, SW-128 and Lindsay Pond were sampled for zoobenthos, emergent insects, phytoplankton, zooplankton and water chemistry Table D-2 summarizes the samples that were taken These data may be used in Problem Formulation and for a weight of evidence approach to the detection of any "impacts" on SW-128

Summary of Preliminary Ecological Findings

Small mammal capture data collected in the Fall of 1993 were inconclusive due to low numbers of captures in both the reference site and the sprayed and non-sprayed sites at OU 11 It is likely that the low numbers of captures are due to the absence of burrowing sites in the upland soils of the WSF A re-sampling of small mammals in OU 11 is scheduled for the spring of 1994 to strengthen the data base and substantiate preliminary findings

Vegetative cover data showed lower basal cover in sprayed versus non-sprayed and reference areas Belt transect data suggested this might be due to the change in species composition resulting from supplemental nitrogen and water additions Subsequently, the production data showed higher plant biomass in sprayed versus non-sprayed and reference areas The data also suggested a much higher litter biomass on sprayed versus non-sprayed and reference areas From these preliminary data, our tentative conclusion is that the water and nitrogen supplement has resulted in a greater biomass of large bunch grasses such as big (Andropogen gerardii) and little bluestem (Schizachyrium scoparium) These results may be analogous to those from watering and fertilizing a lawn heavily and then withdrawing the external treatments, resulting in less cover but elevated litter and biomass

No differences were found between transect locations associated with sprayed versus non sprayed or reference locations in the relative abundance survey Breeding bird results suggest higher bird densities on the WSF than on the reference areas The WSF had the highest population of grasshopper sparrows (Ammondramus savannarum) of any location sampled on the plant site These birds prefer higher stratum grass habitats than other species such as the savannah sparrow (Passerculus sandwichensis) Aquatic habitat species composition at surface water location SW-128 showed no obvious loss of sensitive species Overall, this preliminary evaluation of the available data showed no evidence of biotic effects between the treatment and reference areas associated with historical spraying activities at the WSF

3 3 SOILS SAMPLING

Two historic soil sampling programs were conducted at the WSF to determine if immediate removal actions were necessary The sampling programs took place in 1986 and 1988 to provide information for the Part B RCRA Permit Application (Rockwell International, 1986) The data from sampling indicated that immediate removal actions were not necessary Although the data from these two studies was not validated, the results corroborate each other and therefore, the data has been used only for assessing potential contamination, not for characterization purposes No previous investigation of soils below five feet has been conducted

Surface Soils

Surface Soil Sampling

In 1988, 12 test pits were excavated at points where spray concentrations were expected to be a maximum Thirty-six samples were collected to a depth of five feet and analyzed for constituents known to have been in the applied liquid The analysis included select metals, radionuclides, nitrate/nitrite, and volatile organic compounds (VOCs) These data provided a preliminary view of the contamination at the WSF For comparison purposes, analytical data samples composited from the upper two feet of soil (Layer 1) were compared to Rock Creek analytical data (the upper six inches of soil) and are presented in Appendix C This surficial soil data has been used in the development of the revised FSP

Gamma Surveys

Two gamma surveys have been conducted at the WSF In July of 1989, an aerial gamma survey of the RFP and surrounding areas was performed by EG&G Energy Measurements The aerial survey, which measured gamma radiation, provided an estimate of the distribution of isotope concentrations around the plant Results were reported on isoradiation contour maps and included measurements of americium-241 and cesium-137 (EG&G EM, 1989)

A ground-based High Purity Germanium (HPGe) gamma survey was performed at OU 11 in September and October of 1993 in order to provide baseline information for worker safety during future field investigations, and to aid in the characterization of surface soils The instrument operated at a height of 6 5 meters and measured emissions within a radius of approximately 150 feet Ninety-five percent of the detectable gamma-ray emissions originated within the counting area or field of view (information concerning the capabilities and limitation of the HPGe system can be obtained in the "Compendium of In Situ Radiological Methods and Applications at Rocky Flats Plant" (EG&G, 1993a)) Results of the aerial gamma survey and the OU 11 HPGe survey are presented in Figures 3-3 and 3-4, respectively

Summary

The soil sampling study conducted in 1988 indicated that activities for individual radionuclides were slightly higher at the WSF than those at Rock Creek This information is shown on Table C-4 in Appendix C The 1988 Closure Plan for the WSF (Rockwell International, 1988), which became the 1992 conditionally approved OU 11 Work Plan, stated that the closure performance standards for uranium and plutonium were 32 picoCuries per gram (pCi/g) and 0 9 pCi/g, respectively Although plutonium-239/240 at a mean activity of 0 15 pCi/g for 1988 surface samples is significantly above the Rock Creek background activity of 0 05 pCi/g, it is still well below closure performance standards in the 1988 Closure Plan Uranium sample means for OU 11 were 0 93 pCi/g for U-233,234 and 0 91 pCi/g for U-238, which are lower than Rock Creek background activities of 1 22 and 1 32, respectively

Lead, mercury and nitrate/nitrite were also analyzed in the 1988 soil sampling study Nitrate and lead were present above background concentrations in some samples Some of the results were noted in the original lab report as requiring re-analysis

Results of VOC analyses in surface soils at OU 11 showed the presence of acetone and trichloroethane only Both VOCs are common laboratory solvents ~~and are expected to appear in VOC analyses.~~ ? It is unlikely that VOCs would have been adsorbed onto soil particles because the act of spraying would probably have caused the organic compounds to volatilize and dissipate if present in the spray liquid

Aerial gamma exposure rates measured at OU 11 are lower than those measured on plantsite and other surrounding areas (11-13 micro-rems per hour (μR/h) for OU 11 and 15-17 μR/h for surrounding areas) Figure 3-3 shows gross count exposure rates superimposed on a photograph of the Rocky Flats area (EG&G EM, 1989) Figure 3-4 presents data from the HPGe survey Gamma exposure rates ranged from 5 to 8 μR/h Both studies have shown that surficial gamma radiation at OU 11 is lower than the average for the RFP and surrounding background areas

Subsurface Soils

The spray application at the WSF resulted in low concentrations of contaminants being spread over large areas The evapotranspiration rate is high in the RFP area and constituent concentrations are anticipated to be higher in surface soils than in subsurface soils or groundwater Historical investigations focused on surface and shallow subsurface soil sampling For data comparability purposes, data from soil layers 2 and 3 of the 1988 test pit study were combined, because they are from three to five feet below the surface and are Rocky Flats Alluvium (RFA) materials Data from these layers were compared with background data from the RFA from the Final Background Geochemical Characterization Report (EG&G, 1992c) and are summarized in Table C-5

Activities from radionuclides in subsurface soils at OU 11 were all higher than established background activities (EG&G, 1992c) This difference in activities occurs because the sample means for background radioactivity in the RFA were calculated for deeper intervals than the samples taken at OU 11 Due to the hydrophobic nature of radionuclides, the deeper soils analyzed in the background study should have lower activities than those of OU 11 Because radionuclides tend to "cling" to soil particles, it is expected that they would have higher activities in upper layers of soils (EG&G, 1993c) This behavior is also reflected when comparing the OU 11 sample means for Pu-239/240 in subsurface soils (two feet to five feet in depth), which are less than sample means for Pu-239/240 in OU 11 surface soils activities (one foot to two feet) in depth) by 0 12 pCi (uranium values went up slightly with depth, which is to be expected with naturally occurring radionuclides) Further investigation for radionuclides in subsurface soils is proposed in Section 4 of this TM

Sample means for nitrate and lead were also higher than those for background Further investigation of nitrate/nitrite and metals is proposed in Section 4 for the same reasons mentioned for surface soils

3 4 SURFACE WATER

Surface water data was collected through stations set for the Rocky Flats Surface-Water Monitoring Network in 1989 and 1990 Because standing water does not exist at the WSF, only discharges from storm events could be monitored Background data for storm events is unavailable, and although data comparability is questionable for storm water and surface water Orthophosphate is present in surface water, but it is the most stable of the oxidated phosphorus forms Aluminum, lead and zinc are analytes that appear consistently in surface water, which is expected for leachable metals applied to surface areas No surface water sampling is anticipated as part of this investigation

3 5 GROUNDWATER

RCRA regulations require a groundwater monitoring program be implemented which is capable of determining the impact of a RCRA regulated unit on the upper most hydrostratigraphic unit To meet this requirement, 17 groundwater monitoring wells have been installed at OU 11 Prior to the 1986 RCRA monitoring program, few wells were installed and these have since been abandoned due to incomplete well construction information

Routine groundwater monitoring at the WSF began in 1986 This monitoring is being conducted to provide data for assessment of nature, extent, and migration characteristics of contamination in the unconfined "aquifer", commonly referred to as the upper hydrostratigraphic unit (Rockwell International, 1987) Groundwater flow in the upper hydrostratigraphic unit moves in an east-northeasterly direction with a typical hydraulic conductivity of $4\ 4 \times 10^{-1}$ feet per day (EG&G, 1993b) Fourteen alluvial wells and three bedrock wells are routinely sampled at the WSF Three of these wells are screened through the entire thickness of the RFA and the rest are screened in the 20 foot interval above the bedrock This arrangement adds uncertainty to the understanding of chemical distribution in the subsurface because the wells screened through the entire interval have higher contamination levels than do those completed only in the lower saturated zone, indicating the possibility of contamination in shallow groundwater beneath the WSF (See Section 4 5 for more detail)

Groundwater quality in the upper hydrostratigraphic unit in downgradient wells was compared with that of the upgradient wells and with background groundwater quality (Section 4 5 and Appendix C) and is summarized below

- Volatile organic compounds (VOCs) detected in groundwater were xylene, carbon tetrachloride, and toluene Each of these VOCs were only detected in one sample from one quarter This is indicative of laboratory contamination

- The radionuclides detected at activities exceeding sitewide background levels were americium, plutonium, and tritium Plutonium activity was above the sitewide background value in groundwater from only one well during one quarter

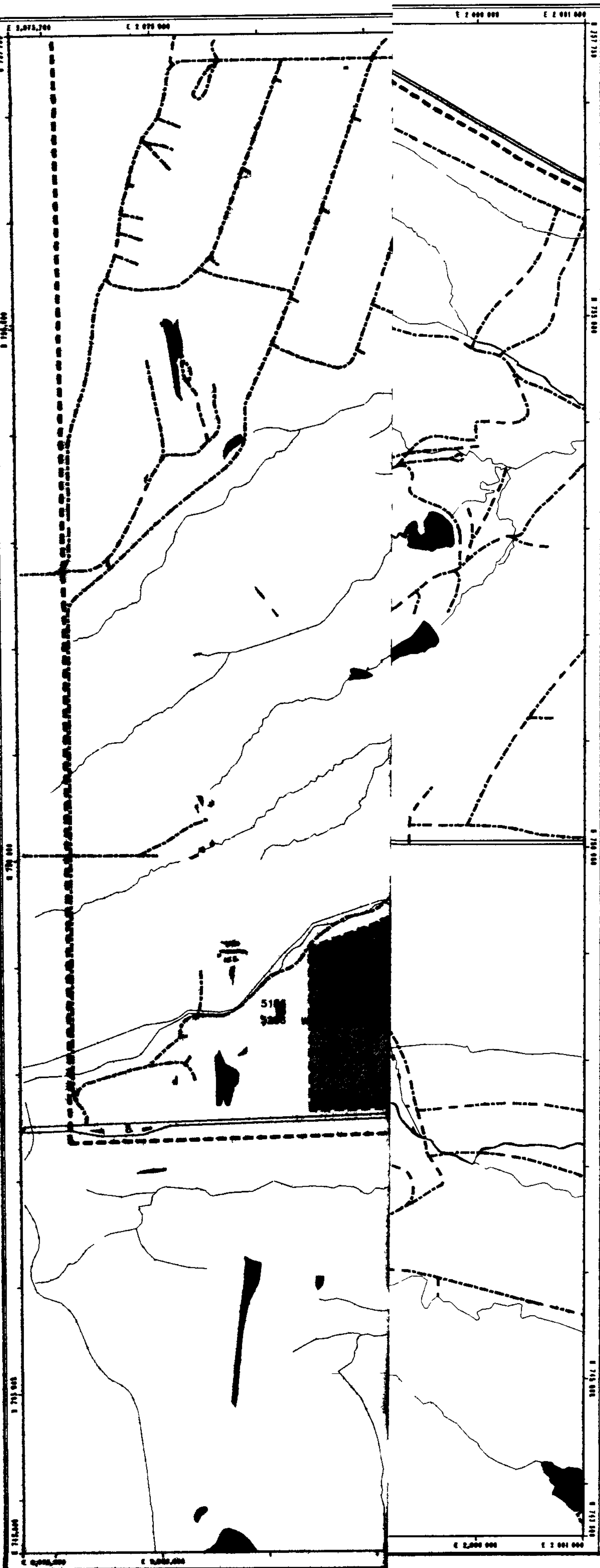
- Concentrations of uranium-233, 234 were detected in five downgradient wells but were within the upper tolerance limits of background values

- Calcium, chloride, fluoride, silicon, and sodium were measured at greater concentrations in the downgradient monitoring wells than in upgradient wells, sulfate, nitrate/nitrite, magnesium and total suspended solids all were measured at higher concentrations in upgradient monitoring well number 5186 than in downgradient wells

A discussion concerning the existence of constituents in groundwater beneath the WSF that are above background levels may be found in Section 4 6, Analytical Requirements Section 4 6 also describes the proposed plan for analysis

Seismic Information

A seismic study was performed in February of 1992 as a part of the Geologic Characterization Data Acquisition Plan (EG&G, 1992d) Data from the seismic study will not be used for OU 11 characterization purposes until the data is verified through the drilling proposed in this TM The seismic information is considered unusable for this very shallow WSF study due to calibration issues If drilling information proves the seismic instrumentation to have been calibrated correctly, data from the seismic study will be used in the RFI/RI Report The location of the seismic line at the WSF can be seen in Figure 4-2



OU11/IHSS-168 Basemap
West Spray Field
Sample Locations for OU11 and Background Studies

Figure 3-1

EXPLANATION

- Spray Area
- Approximate Area of 1986 Soil Sampling
- ● OU11 SW Locations
- ● OU11 Alluvial GW Locations
- ● OU11 Bedrock GW Locations
- ● OU11 Soils Locations
- ▲ Background Alluvial GW Locations
- ▲ Background Bedrock GW Locations
- ▲ Background Soils Locations
- IHSS 168 (OU11)
- Piping (Historical)

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Rocky Flats boundary
- Paved roads
- Dirt roads

Scale = 1 : 10800
1 inch = 900 feet

State Plane Coordinate Projection
Colorado Central Zone

U.S Department of Energy
Rocky Flats Plant

Prepared by:

EG&G ROCKY FLATS

Rocky Flats Plant
P.O Box 464
Golden, Colorado 80402-0464

None Assigned	GIS Analyst		
*** Draft ***	Checked		
March 22, 1994	Approved		

Figure 3-2 Ecological Soil Sampling Scheme

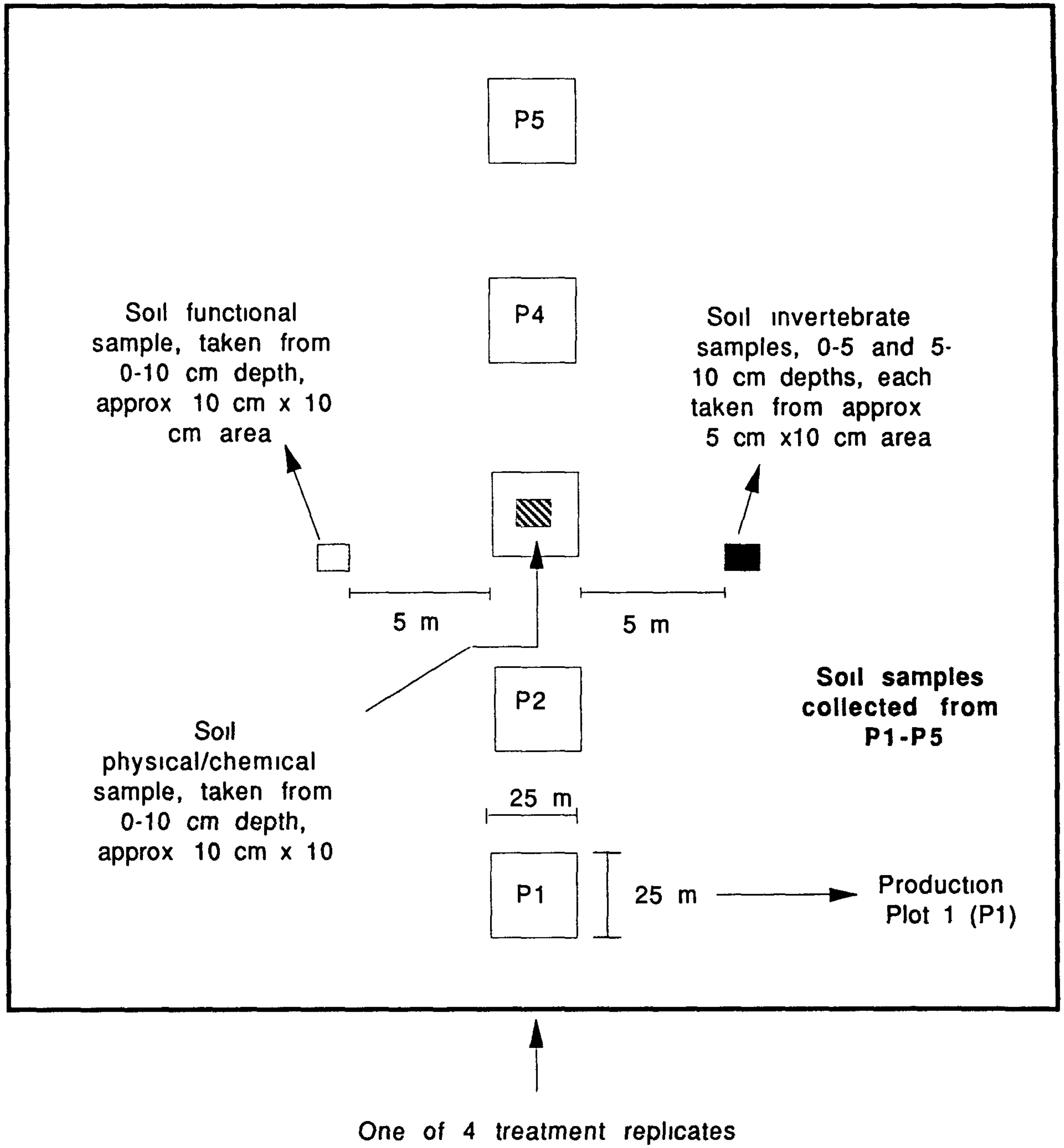
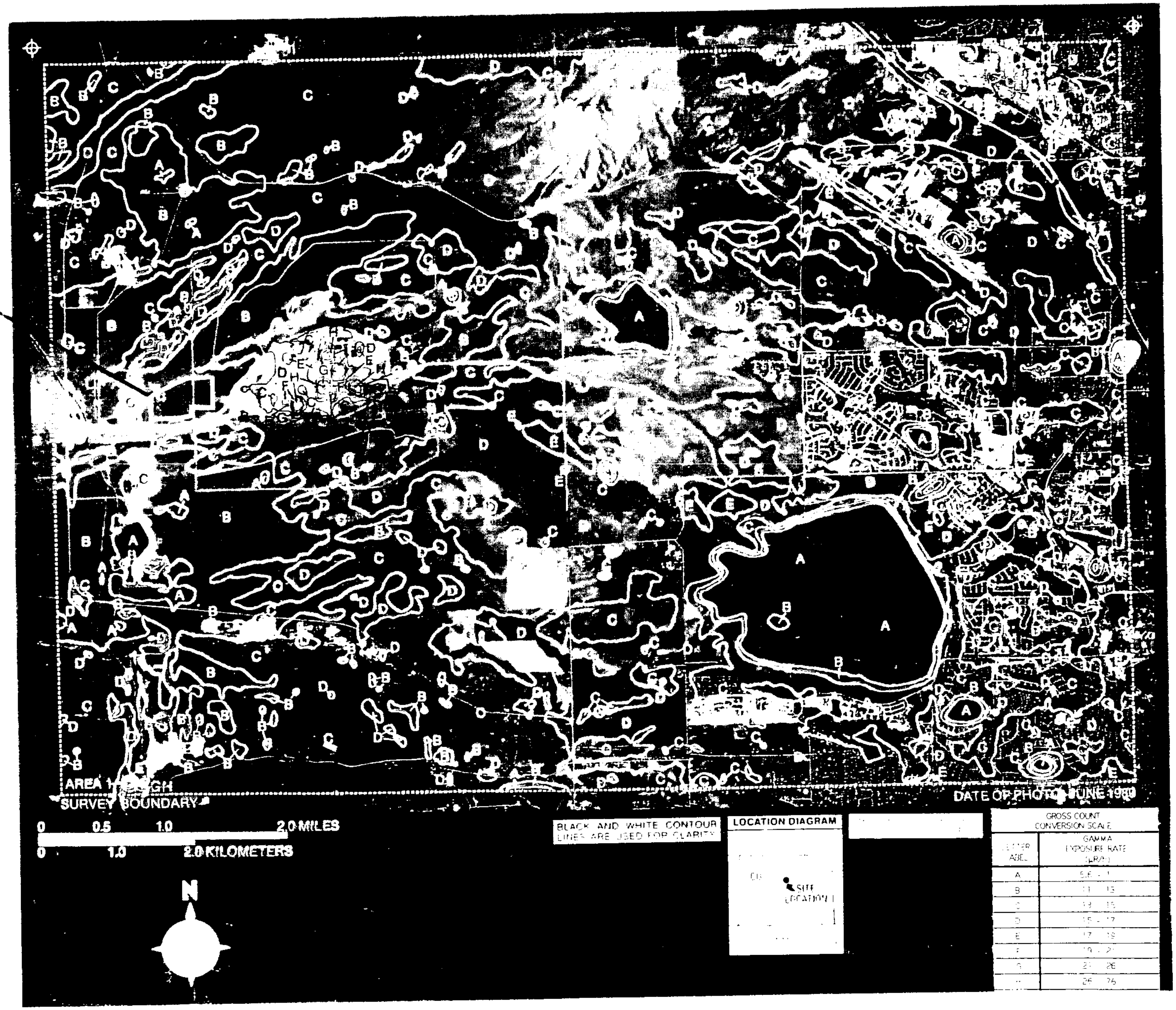


FIGURE 3-3
1989 AERIAL GAMMA SURVEY ISOPLETH MAP OF OU 11 AND SURROUNDING AREAS

Area of 1993 HPGe Survey for OU 11.
The West Spray Field Gamma Exposure Rate: 11-13μR/h



TERRESTRIAL GAMMA RAY EXPOSURE RATE AT 1 METER ABOVE TERRAIN EXTRACTED FROM THE GROSS COUNT RATE DATA

4.1 OBJECTIVES AND APPROACH

The objective of this FSP is to provide the scope for collecting additional data necessary to sufficiently characterize the WSF in order to evaluate the potential risk from the site The RFI/RI Report and risk assessment for OU 11 require adequate data coverage of the area Data gaps were identified by assessing historical data, performing preliminary investigations (i e the ground-based radioisotope survey), and determining parameters needed to fully evaluate contamination pathways Each section described below provides justification for locations, amounts, and types of sampling In addition, process knowledge of Solar Pond water constituents, known locations of areas that received maximum spray, and geologic modeling information are taken into account Table 4-1 presents a comparison of sampling activities from the original OU 11 Work Plan (EG&G, 1992a) and revisions to that Work Plan as presented in this TM Table 4-1 also presents justifications for revisions to the original OU 11 Work Plan Table 4-2 summarizes the activities detailed in this TM

4 2 ECOLOGICAL FIELD SAMPLING PLAN

Proposed sampling activities which have not been completed to date are highlighted in Table D-1, and an explanation as to the status of these activities is provided in the footnotes of this table Pellet counts are scheduled for sampling in the spring of 1994 All proposed tissue sampling or proposed tissue sample analyses await the results of the problem formulation and regulatory agency guidance as to the efficacy of this effort for OU 11 Quantitative sampling of aquatic biota may occur during the spring of 1994 pending problem formulation and regulatory agency guidance

The Ecological Evaluation/Ecological Risk Assessment for OU 11 will be prepared following a three-phased approach based upon the EPA's *Framework For Ecological Risk Assessment* (EPA, 1992), and will consist of the following

A. Problem Formulation,

B Analysis - Characterization Of Exposure and Characterization of Ecological Effects, and

C Risk Characterization if any adverse effects are observed

At the conclusion of each phase, a formal presentation will be given to the regulatory agencies along with a report for review and concurrence

4 3 SOIL SAMPLING PLAN

Surficial Soil Sampling Plan

Fewer surface soil samples are required for the investigation of potential contamination of the WSF than are proposed in the conditionally approved OU 11 Work Plan (EG&G, 1992a) Analysis of available data, statistical power considerations for comparing site and background means, and the inapplicability of hot spot detection (due to the method of spray application) all indicate the need for fewer samples The original FSP called for a uniform sampling grid over the entire spray field with 300 foot spacings which resulted in the need for collecting and analyzing 75 surface soil samples Adequate comparisons to background and additional comparisons within the spray fields can be made based on fewer samples A sampling scheme that will allow comparisons of spray and channel areas within the spray fields is presented

In an attempt to meet power criteria in the comparison of site and background, along with a desire to detect hot spots, the need for 75 surficial soil samples ~~resulted in the FSP from the~~ was presented in the original OU 11 Work Plan (EG&G, 1992a) With a grid spacing of 300 feet, to detect an existing hot spot with probability of 90, the appropriate statistical standard, the hot spot would need to have a diameter of approximately 168 feet To attain the same detection probability for a 50 foot hot spot, the grid for the WSF would require 1000 surface soil samples (see Appendix E for a thorough explanation)

In areas of potentially greater risk, the sampling design should determine if analytes are elevated with respect to other areas within the OU as well as with respect to background This design should be applied to the WSF, as the areas of higher risk are the areas of spray application, which are well documented, and runoff channels, which can be located on aerial photos The revised surface soil sampling plan allows for the comparison of runoff channels, spray areas, and areas that were neither sprayed or runoff channels

This surficial soil sampling plan abandons the systematic grid approach for detecting hot spots in favor of specifically locating samples in areas of special interest For the WSF, such areas are the discharge channels and spray contact areas It is recommended that 11 samples be taken from channels within spray areas, 7 samples be taken from channels outside of spray areas, 10 samples be taken from outside channels in spray areas, and 6 samples be taken from outside of both runoff channels and spray areas (Figure 4-1) This gives a total of 34 samples and provides data on which to base internal OU comparisons The locating of samples within the various areas could be done randomly, but this approach is not necessary for reasonable inferences to be made

Surface soil sampling will be performed in accordance with the "Rocky Flats Method" as outlined in SOP GT 08 This method requires the compositing of five samples for each sample location, generating data from a larger area The "Rocky Flats Method" was the method used for background sampling, and therefore should be used at the WSF for comparison purposes Adequate characterization of surface and shallow subsurface materials can be obtained from the sampling activities proposed in this section

Subsurface Soil (Sediment) Sampling Plan

Subsurface Soils will be sampled from the monitoring well locations described Section 4 5 and Figure 4-2 As detailed in Section 4 5, two foot composite samples will be taken from ground surface to a depth of 30 feet Upon encountering perched water, equipment for monitoring groundwater will be installed If perched water is not encountered, six foot composite samples will be taken from 30 feet to the saturated zone Approximately 120 borehole samples will be taken using this sampling strategy Section 4 5 details sampling methodology

Geophysics
find out from Tim Lovseth

1 more paragraph at least

4 4 SURFACE WATER

This revised FSP does not include sampling for surface water Since no permanent surface water exists at OU 11, only storm events can be monitored at OU 11 The only analytes that appear above background are essential nutrients and major rock constituents (even the comparison to background is questionable, as background figures are from pond sampling) Finally, any surface contamination that would cause surface water runoff contamination will be examined through the surface soil sampling program described previously

4 5 GROUNDWATER MONITORING PLAN

Current Monitoring Network

An extensive network of groundwater monitoring wells exists in or near OU 11 These wells are screened in the uppermost hydrostratigraphic unit (RFA) for the purpose of monitoring the saturated zone This network includes two upgradient wells, five wells within the WSF boundary, six wells on the downgradient IHSS boundary, and an additional eight wells downgradient or to the sides of the IHSS This monitoring design was developed to monitor the non-point source dissemination of potential contaminants into the environment

Perched Groundwater Conditions

Data supporting the existence of perched groundwater include historical water level data, water chemistry data, and information gathered during recent drilling operations If WSF spray activities have contributed significant levels of contamination to the groundwater, perched areas of groundwater have the potential of having the highest levels of contamination

The screened intervals of the wells in the current monitoring system are either too deep to monitor perched conditions, or are screened through the entire thickness of the RFA The three wells with extensive screened intervals are 4986, 5186, and B410789 Nitrate/nitrite has been detected in all three wells at concentrations ranging from approximately 3 to 8 milligrams per liter (mg/l) during the past several years These concentrations do not constitute a concern in terms of nitrate/nitrite groundwater quality standards (10 mg/L), (EPA 1993b), however, they may represent a dilution of shallow (perched) groundwater contamination with deeper groundwater from the saturated zone

Four wells (1081, 582, 682, and 782) were drilled in the WSF area to depths of approximately 25 feet for the purpose of monitoring shallow groundwater conditions Water level measurements taken at these locations indicate that shallow groundwater exists at depths of between 20 and 25 feet Because well construction details for these wells were not available, all four wells were recently abandoned through WARP (Well Abandonment and Replacement Program)

Additional evidence of perched groundwater conditions was obtained when replacement wells 46192 and 46292 were drilled to bedrock These wells were drilled with hammer technology using air as a drilling fluid Sample returns indicated that water was encountered at a depth of approximately 25 feet

Locations of Proposed Boreholes and Monitoring Wells

For the purpose of obtaining additional subsurface information, six wells will be installed in the WSF (Figure 4-2) The main criterion for the selection of well locations was that the wells be located within the irrigation sub-basins or areas which received direct spray application Additional criteria included proximity to wells where contamination has been documented, proximity to wells where shallow groundwater was encountered upon drilling of wells previously abandoned, position relative to surface runoff pattern, and position relative to the seismic data

Seismic data were evaluated as a tool for locating boreholes and wells, however it was concluded that the WSF seismic line had not been adequately calibrated to the subsurface geology In addition, seismic processing was intended to enhance deeper portions of the geologic section rather than the uppermost 30 feet, where perched mounds are anticipated For the purpose of validating the seismic data for future use, two boreholes will be located on the seismic line Listed below are the well locations for the six proposed wells

WSF-1	Located in Spray Area 1, between wells with elevated nitrate/nitrite contamination, where perched conditions have been encountered and where surface runoff drainage resulted from spray application
WSF-2	Located in Spray Area 1, near well 5186, where elevated nitrate/nitrite concentrations have been encountered, and on the seismic line
WSF-3	Centrally located in the southern portion of Spray Area 1, on a surface runoff drainage resulting from spray application
WSF-4	Located in Spray Area 2, near well 0582, where the highest historical record of nitrate/nitrite in West Spray Field groundwater was recorded
WSF-5	Located in Spray Area 2 on the seismic line
WSF-6	Centrally located in Spray Area 3, where there is a lack of data

Monitoring Well Installation Program

As described above, six boreholes will be drilled for the purpose of characterizing subsurface lithologies and sampling perched water conditions if present (detailed later in this section) Results from drilling, borehole sampling, and groundwater monitoring will be used to assess the need for further characterization of OU 11

Activities related to the Monitoring Well installation Program will be carried out in accordance with all applicable Environmental Management Division SOPs The following EMD SOPs are applicable in this program

FO 01	Monitoring and Dust Control
FO 02	Transmittal of Field QA Records
FO 03	General Equipment Decontamination
FO 04	Heavy Equipment Decontamination
FO 05	Handling of Purge and Development Water
FO 06	Handling of Personal Protective Equipment

FO 07	Handling of Decontamination Water and Wash Water
FO 08	Handling of Drilling Fluids and Cuttings
FO 09	Handling of Residual Samples
FO 10	Receiving, Labeling, and Handling Environmental Materials Containers
FO 11	Field Communications
FO 12	Decontamination of Facility Operations
FO 13	Containerization, Preserving, Handling, and Shipping of Soil and Water Samples
FO 14	Field Data Management
FO 16	Field Radiological Measurements
FO 18	Environmental Sample Radioactivity Content Screening
FO 23	Management of Soil and Sediment Investigative Derived Materials (IDM)
GW 01	Water Level Measurements in Wells and Piezometers
GW 02	Well Development
GW 05	Field Measurement of Groundwater
GW 06	Groundwater Sampling
GT 01	Logging Alluvial and Bedrock Material
GT 02	Drilling and Sampling Using Hollow-Stem Auger Techniques
GT 04	Rotary Drilling and Rock Coring
GT 05	Plugging and Abandonment of Boreholes
GT 06	Monitoring Well and Piezometer Installation
GT 10	Bore hole Clearing
GT 17	Land Surveying
GT 24	Approval Process for Construction Activities on or near IHSSs

Justification of Preferred Drilling Technology

Sonic Drilling and split spoon sampling are the preferred drilling and sampling technology to be used The advantages of utilizing sonic drilling are summarized below A Document Modification Request (DMR) pertaining to sonic drilling will be written for EMD SOP GT 04, Rotary Drilling and Rock Coring

Achieving good sample recovery for lithologic and chemical characterization is the main objective of using sonic drilling Most of the wells previously drilled on OU 11 were drilled with hammer technology Lithologic logs of these wells lack accuracy and detail Hollow-stem auguring, the standard method of drilling boreholes at RFP, can provide undisturbed samples for analyses, and this technique may be adequate, however there is a risk of obtaining poor sample recovery in the unconsolidated sands and gravels of the RFA Because the perched zones of interest are relatively thin, good sample recovery is critical to characterization efforts

Sonic drilling technology has a distinct advantage for use at RFP over conventional auger and percussion drilling because it allows continuous sample retrieval through cobbles and boulders By utilizing a relatively high-frequency oscillating drill head combined with downward pressure and low rotation, the drill string is advanced through unconsolidated and consolidated materials Additional advantages of sonic drilling are its rapid rate of penetration, the generation of small drilling waste volume at the drill site, and the speed and ease of development of monitoring wells (critical in perched zones where little water may be available for well development)

Sonic drilling has a limited track record in the environmental industry Approximately two years ago, sonic drilling was used for a site assessment of the RFP Wind Site The program was experimental and involved modifications to standard sonic drilling equipment Problems with sample recovery were encountered, including plugging of the drill bit and recoveries of greater than 100 percent (probably due to expansion of sample and extension of the sample in the core barrel which has a smaller diameter than that of the drilling bit) Sonic drilling technology has improved since it was employed at the Wind Site, and reports of is success at other sites, such as Hanford, have been received However, due to the limited use of sonic drilling in the environmental industry, the first well at the WSF will be a test case If drilling objectives are successfully met, the remaining five wells will be drilled in a similar manner In the event that sonic drilling is not successful in a test case scenario, hollow stem augering will be used as an alternative

Drilling Procedures and Borehole Sampling

As stated above, Sonic Drilling will be employed, and core samples will be collected in a split spoon sampler Visual logging of the alluvial materials will be performed according to SOP GT 01, Logging of Alluvial and Bedrock Material All sampling equipment will be protected from the ground surface with clear plastic sheeting Sampling procedures are defined in SOP GT 02, Drilling and Sampling Using Hollow-Stem Auger Techniques In addition, samples for water content measurements will be collected every two feet Water content measurements will be determined in the field and also in a geotechnical laboratory Water content data for each borehole will be collected in the field using a "Speedy Soil Moisture Tester", manufactured by Soiltest Incorporated or other field water content instrument, and will be used to design each monitoring well Samples released to the geotechnical laboratory will be stored after analysis for future use, if future vadose zone characterization is deemed necessary These samples might be used to construct moisture characteristic curves Drilling and sampling activities will be conducted in accordance with the OU 11 Site-Specific Health and Safety Plan

All drilling equipment, including the rig, water tanks, drill rods, samplers, etc , will be decontaminated before arrival at the work site The drill rig will be decontaminated between each borehole, and sampling equipment will be decontaminated between samples Equipment will be inspected for evidence of fuel oil or hydraulic system leaks SOP FO 03, General Equipment Decontamination and SOP FO 04, Heavy Equipment Decontamination will be adhered to If lubricants are required for down-hole equipment, only pure vegetable oil will be used

Prior to drilling, approval for construction activities will have been obtained in accordance with SOP GT 24, and drill sites will have been cleared in accordance with GT 10 Well locations will have been surveyed, numbered, and identified with stakes During site preparation, an exclusion zone will be established according to the Site-Specific Health and Safety Plan, and the drill rig will be set up The objective of well installation is to monitor groundwater quality in potentially contaminated perched mounds The monitoring network in the saturated zone is complete, and no new wells will be constructed to monitor this portion of the uppermost hydrostratigraphic unit The total depth of each well will be determined by the project manager Holes will be drilled to penetrate a perched saturated zone (if encountered) and underlying aquitard If a perched groundwater table is encountered, a monitoring well will be installed in accordance with this TM If a perched groundwater table is not encountered, the boring will be advanced to the saturated zone At that time the project manager will determine if the bore hole should be abandoned in accordance with GT 05 or drilled to the alluvial/bedrock contact for the purpose of supporting the OU 11 data acquisition plan Since OU 11 subsurface lithologic data is incomplete, boreholes may be advanced to penetrate the entire RFA After a borehole has been advanced to penetrate bedrock, it will be abandoned in accordance with GT 05 Boreholes will be sampled in accordance with SOP GT 02, Drilling and Sampling Using Hollow-Stem Auger Techniques or in accordance with a DMR for a split core sampler used with a sonic drilling rig, depending upon the most appropriate technology as determined by subsurface conditions Boreholes will be lithologically logged in accordance with SOP GT 01, Logging Alluvial and Bedrock Material During drilling operations, the cuttings will be containerized according to SOP FO 08, Handling Drilling Fluid and Cuttings and FO 23, Management of Soil and Sediment Investigative Derived Materials (IDM)

How About GEOPhysical Logging?

For the purpose of defining extent of contamination, soil samples will be collected from ground surface to the saturated zone At each boring location, discrete two-foot composite samples for chemical analyses will be collected from ground surface to a depth of 30 feet Based on existing data it is anticipated that perched mounds with the potential for significant contamination may exist at depths less than 30 feet If perched water is not encountered at or before 30 feet, then, six-foot composite samples will be collected from a depth of 30 feet to the saturated zone Figure 4-3 summarizes the drilling decisions and subsequent activities flow

Samples will be analyzed for the analytical parameters as defined in Section 4 6 ~~In order to collect these composite samples, the recovered material will be placed in a safe location, out of direct sunlight, until the appropriate number of core samples have been collected~~ The recovered material will be classified, logged, peeled disaggregated, mixed into a composite, and placed in appropriate containers for laboratory analysis according to SOP FO 13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples Procedures for sample peeling, handling and compositing will be followed according to SOP GT 02, Drilling and Sampling Using Hollow Stem Auger Techniques

Subsequent to sample collection the exterior of the sample containers will be decontaminated according to FO 03, General Equipment Decontamination, and placed in coolers lined with a plastic bag designated for sample transportation Blue ice or equivalent will be placed in each cooler Official custody of samples will be maintained and documented from the time of collection until the time that valid analytical results have been obtained or the laboratory has been released to dispose of the sample Chain-of-Custody procedures will be in accordance with SOP FO 13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples

Monitoring Well Installation Procedures

As specified in the IAG, groundwater monitoring wells will be installed according to SOP GT 06, Monitoring Well Installation, which is outlined below

The screen intervals of all wells will be sufficient to monitor perched groundwater conditions The well design specifics for each well will be determined after the bore hole has been drilled and the water content measurements and lithologic data have been analyzed It is anticipated that the well will be two inches in diameter upon completion However, since new drilling technologies are anticipated, the casing size will be evaluated so that the ratio of filter pack to well diameter is appropriate The objective is to maintain an approximate two inch filter pack around the well bore annulus Well casings will consist of new, threaded, flush-joint, schedule 40 poly-vinyl chloride (PVC) The well casing will extend from the top of the well screen to approximately two feet above ground surface The tops of all well casings well be fitted with slip-on or threaded PVC caps All joints within the casing string will be threaded O-rings will be used, or polytetrafluoroethylene (PTFE) tape will be wrapped around the joint threads to improve the seal All well casings will be steam cleaned and stored in plastic sleeves prior to use

Well screens will be placed in a manner to optimize the groundwater flow from the perched zone into the well bore The bottom of the screened interval will coincide with the top of the underlying aquitard Well screens will consist of new threaded PVC pipe with the 0 010-inch factory-machined slots or wrapped screen The wall thickness will be the same as the well casing, so that the screen Inner Diameter (ID) is equal to or greater than that of the well casing A sediment sump will be constructed beneath the screen, such that the sump extends at least six inches below the perched aquifer but does not extend below the bottom of the aquitard If the aquitard is greater than two feet thick, a two-foot deep sediment sump will be constructed

Filter pack material will be chemically inert, rounded silica sand of approximately 16-40 gradation The particulars of filter pack placement will depend on the thickness of the perched water zone and underlying aquitard The filter pack will extend approximately two feet above the well screen and at least six inches below the well screen base If the aquitard is of sufficient thickness for a two-foot sediment sump, the filter pack will extend two feet below the bottom of the well screen

Bentonite pellet seals will be installed above and below the filter pack for the purpose of isolating the perched water zone The bottom seal will consist of a minimum of three feet of bentonite pellet backfill material, and the upper seal will consist of a minimum three-foot bentonite pellet layer, installed between the formation and well casing The thickness of the bentonite seals should be measured immediately after placement, without allowance for swelling Bentonite should be placed in a manner so that it does not get hung up in the screened interval during emplacement, as bentonite can alter the pH of the formation water

Monitoring Well Development and Sampling Procedures

Monitoring wells will be developed for groundwater sampling as specified in SOP GW 02, Well Development Monitoring well development is the process by which the well drilling fluids and mobile particulates are removed from within and adjacent to newly installed wells The objective of well development activities is to provide groundwater inflow that is as physically and chemically representative as possible of the hydrostratigraphic unit or aquifer

Well development will be conducted as soon as practical after installation, but no sooner than 48 hours after grouting and pad installation is completed Monitoring wells will be developed utilizing low energy methods An inertial pump or bottom discharge/filling bailer will be used in development activities

All newly installed wells will be checked for the presence of immiscible layers prior to well development Once determined free of an immiscible layer, a water level measurement will be taken according to SOP GW 01, Water Level Measurements in Wells and Piezometer, and well development activities will proceed The water level measurement along with the total depth measurement and the diameter will be used to determine the volume of water in the well casing

Formation water and fines will be evacuated by slowly lowering and raising the inertial pump or bailer intake throughout the water column Development equipment, including bailers and pumps, will be protected from the ground surface with clear plastic sheeting The equipment will be decontaminated before well development begins and between well site activities according to SOP FO 03, General Equipment Decontamination

Estimated recharge rates will be measured following the procedures outlined in SOP GW 01, Water Level Measurements in Well and Piezometers

Groundwater sample collection will be performed in accordance with SOP GW 06, Groundwater Sampling The groundwater will be sampled and analyzed for analytes included in the Analytical Requirements section (Section 4 6) of this TM, provided sufficient groundwater is collected

The following field measurements will be obtained at the time of sample collection

- pH
- specific conductance
- temperature
- dissolved oxygen
- barometric pressure

If there is not enough groundwater to sample for all analytes, the analytical priority stated in the Analytical Requirements section (Section 4 6) will be followed Samples will be handled according to SOP FO 13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples, and FO-03, General Equipment Decontamination

4 6 ANALYTICAL REQUIREMENTS

Surficial Soils

The analytical suites for surficial soil samples were developed based on Solar Pond water analyses (Appendix A), historical sampling results, and the geochemical behavior of contaminants Target Analyte List (TAL) Metals can be found in Appendix F of this TM Surficial soil samples collected for this sampling program will be analyzed for the following

- Uranium 233/234, 235, 236, and 238,
- Plutonium and Americium,
- Tritium,
- TAL Metals, and,
- Nitrates

Surficial soil samples will not be analyzed for volatile and semi-volatile organic compounds due to the volatile nature of the compounds and the elapsed time since the last spray application This list of analytical parameters is similar to that in the original OU 11 Work Plan (EG&G, 1992a) The original Work Plan also recommends additional suites for analysis for test pit samples Those analytes will be examined through the drilling program

Subsurface Soils

As mentioned earlier, the analytical requirements for subsurface soils (RFA materials) is equivalent to the test pit sampling parameters in the original OU 11 Work Plan Target Compound List (TCL) organics can be found in Appendix F Subsurface soils will be analyzed for the following chemical and radionuclide parameters or parameter groups

- TAL Metals,
- Uranium 233/234, 235, 236, and 238,
- Plutonium and Americium,
- Tritium,
- TCL volatile organics, and,
- TCL semi-volatile organics

Groundwater

If perched groundwater is encountered, the following analytical parameters will be analyzed in the priority as listed if groundwater volumes are not enough to allow for sampling of all parameters

- •Nitrates,
- •Uranium 233/234, 235, 236, and 238,
- •Plutonium and Americium,
- •Tritium,
- •TAL Metals,
- •TCL volatile organics, and,
- •TCL semi-volatile organics

Logic for the priority listing is as follows

Priority	Analyte	Logic
1	Nitrates	Process knowledge demonstrates that nitrates were a major constituent of spray water, and nitrates exist at varying levels in different wells at the WSF
2	Radionuclides	Historical analyses of Solar Pond water showed low concentrations of radionuclides
3	TAL Metals	TAL metals are included for a complete analysis
4	Volatile organics Semi-volatile organics	Volatile and semi-volatile organic compounds are the least likely expected contaminant, as they did not appear in Solar Pond water analyses and would likely have volatilized upon spraying

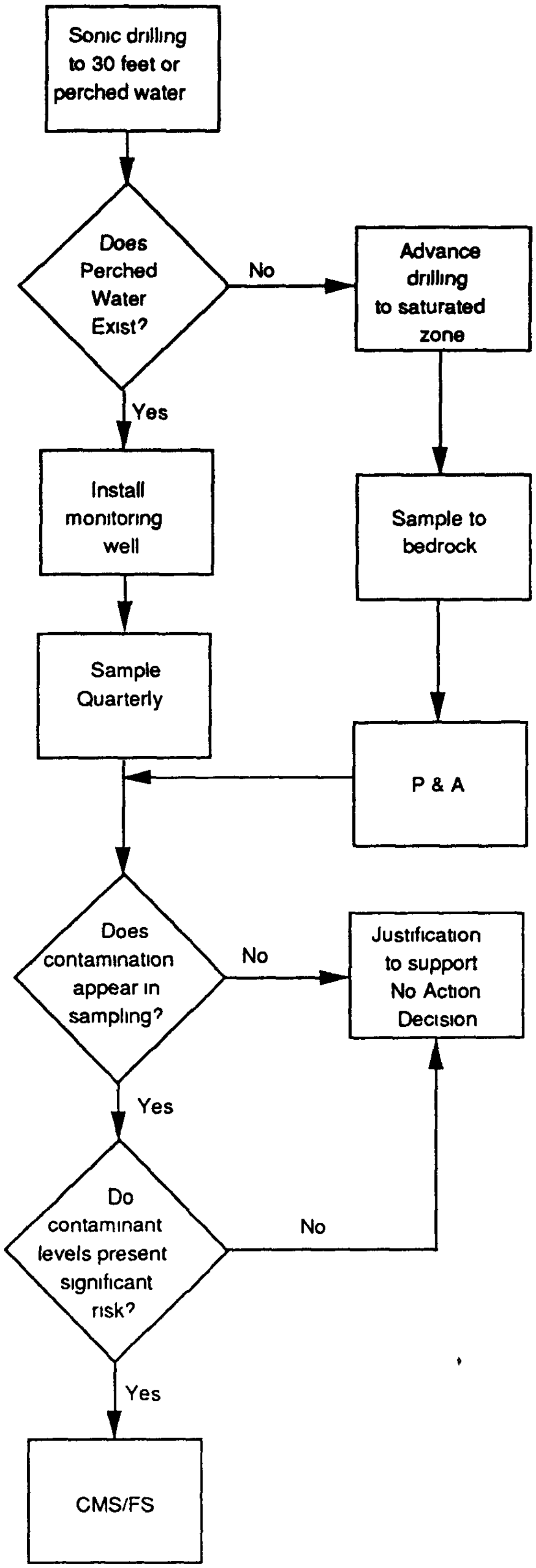
Table 4-1
SUMMARY OF MODIFICATIONS TO THE ORIGINAL OU 11 FSP

ORIGINAL FSP	MODIFIED FSP	JUSTIFICATION FOR MODIFICATION
Review new data	Statistically analyze data, compare constituents with RFP background data	Data should be compared statistically with background data to determine further need to analyze media and certain constituents
Radiation (FIDLER) survey	High Purity Germanium Survey	Determine if anomalous surface radiation exists and should be studied as intensively as proposed in the original field sampling plan Also provides screening for worker safety
Review existing and ongoing geological studies	Review all data	All site data need to be reviewed in conjunction with OU 11 to redefine the scope of the revised FSP
75 Surficial Soil Samples	34 Surficial Soil Samples	Based on historical surficial soil sampling and HPGe results, 75 samples are not necessary Reducing the size will give a statistically defensible number of samples for assessment of risk
48 Test Pit Samples	No Test Pit Samples	For the same reasons as listed in the surficial soil sampling category, but also to reduce the ecological damage that test pit sampling can cause Depths that would be studied in Test Pits will be sampled in 2' intervals at 6 borehole locations
Unknown number of Borehole Samples (Phase II)	120 Borehole samples	Six boreholes are proposed to provide additional site data and fill the data gap that lies in the upper portion of the upper hydrostratigraphic unit Approximately 120 samples will be taken from the 6 boreholes
16 Sediment Samples (surface water)	No Sediment Samples	Surface water does not exist at the West Spray Field Furthermore, statistical comparisons to background of nearby surface water monitoring stations do not indicate contamination from OU 11
Unknown Number of Subsurface Water Samples	6 Monitoring Wells Installed to Monitor Perched Water	If perched water is encountered during the drilling of the 6 boreholes, monitoring wells will be installed to enable the collection of perched water samples
Ecological Field Sampling	Reduced Ecological Field Sampling	Ecological field studies will be supplemented by ongoing sitewide studies

Table 4-2
SUMMARY OF PROPOSED FIELD SAMPLING ACTIVITIES AT OU 11

ACTIVITY	PURPOSE	METHOD	ANALYTICAL PARAMETERS	SAMPLING FREQUENCY	NUMBER OF SAMPLES
GROUNDWATER SAMPLING					
Analytical Sampling	To determine if contamination exists in OU 11 groundwater due to historical spraying activities	Standard operating procedures as discussed in Section 4	Nitrates Uranium Plutonium Americium Tritium TAL Metals TCL VOCs TCL semi-VOCs	Six groundwater monitoring wells to be sampled initially and quarterly thereafter	24 annual samples(four quarterly samples of six groundwater monitoring wells)
Water Content	To determine if perched water zones exist above the saturated zone	Field measurement methods using "Speedy Soil Moisture Tester" or gravimetric methods and subsequent laboratory analysis	Percentage Measurement	Samples for water content measurement will be collected every two feet until the saturated zone is reached	Approximately 90
Water Quality	To detect abnormal conditions in groundwater	Field analysis methods	pH specific conductance temperature dissolved oxygen barometric pressure	Six groundwater monitoring wells to be sampled initially and quarterly thereafter	24 annual samples(four quarterly samples of six groundwater monitoring wells)
SOIL SAMPLING					
Surface Soil Samples	To determine the extent of contamination in surface soils from historical spraying activities	EMD-OP GT 8	Uranium 233/234, 235, 236, and 238 Plutonium Americium Tritium TAL Metals Nitrates	once	34
Sediment Samples/ Boreholes	To provide subsurface, geologic, lithologic and analytical data	Sonic drilling will be employed, and core samples will be collected in a split spoon sampler or by using the core barrel method	TAL metals Uranium 233/234 235 236, 238 Plutonium Americium Tritium TCL volatile organics TCL semivolatile organics	Two-foot composite samples form the surface to a depth of approximately 30 feet, six foot samples from 30 feet to the saturated zone	Approximately 120

FIGURE 4-3 DRILLING LOGIC DIAGRAM



This section consists of the Quality Assurance (QA) information for the combined phases RFI/RI investigation at OU 11 Information presented herein supplements the Rocky Flats Plan Site-Wide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities or QAPjP (EG&G, 1992b) and the Quality Assurance Addendum Section (Section 10) of the original OU 11 Work Plan (EG&G, 1992a)

The FSP detailed in this TM addresses the procedures for conducting the proposed field activities as well as the proposed analytical suites for the samples collected during the field investigation This portion of the FSP identifies QA objectives for data collection, analytical procedures, calibration, and data reduction, validation and reporting All field and analytical procedures will be performed in accordance with the methods described in the QAPjP and SOPs unless otherwise specified in this FSP

5 1 Internal QC Control Samples

The objective of the QAPjP is to provide a framework to ensure that all sampling and analytical data achieve specific data quality standards These standards ensure that PARCC parameters for the data are known and documented All samples sent for Contract Laboratory Program (CLP) analyses will be handled in accordance with CLP guidelines Quality Control (QC) procedures for non-CLP methods will be developed as needed using standard methods

QC samples will be collected in conjunction with the investigative samples to provide information on data quality Equipment rinsate blanks, field duplicates, laboratory blanks, laboratory replicates, and laboratory matrix spike and matrix-spike duplicates will be collected Trip blanks will also be collected for volatile organic analyses

Rinsate blanks will be collected by pouring deionized water through decontaminated sample-collection equipment and will be submitted for the same analyses as the investigative samples

Rinsate blanks monitor the effectiveness of decontamination procedures

Field duplicates will be collected and analyzed to provide information regarding the natural variability of the sampled media as well as evaluate analytical precision Table 5-1 presents the suggested field QC sample collection frequency

Analytical procedures and conditions are tested using laboratory blanks and replicates Laboratory matrix spikes and matrix-spike duplicates measure analytical accuracy by providing data on matrix effects/interferences and components interfering with instrument responses The frequency of collection and analysis of laboratory QC samples is dictated by the prescribed analytical method as cited in the GRRASP (EG&G, 1990)

5 2 Accuracy

Accuracy is a quantitative measure of data quality that refers to the degree of difference between measured or calculated values and the true value One of the measures of analytical accuracy is expressed as percent recovery of a spike of a known concentration that has been added to an environmental sample before analysis (EG&G 1992b) The control limits that have been established to achieve accuracy objectives for Level IV (CLP routine analytical services) data quality are outlined in Table B-1 of Appendix B in the QAPjP (EG&G 1992b) Accuracy limits for inorganic analytes are also listed in Table B-1 Samples requiring 24-hour turnaround (i e , indicator parameter analyses) have accuracy objectives consistent with Level III (off-site lab analyses) data quality The analyses for indicator parameters are non-CLP Non-CLP analyses will be conducted according to SW-846 (EPA, 1990) The accuracy criteria for these samples are specified in the respective methods

5 3 Precision

Precision is a quantitative measure of data quality that refers to the reproducibility or degree of agreement among replicate measurements of a single analyte Analytical precision for a single analyte may be expressed as a percentage of the difference between results of duplicate samples and matrix spike duplicates for a given analyte (EG&G 1992b) The control limits that have been established to achieve precision objectives for Level IV data quality are outlined in Table

B-1 of Appendix B in the QAPjP (EG&G 1992b) Precision limits for inorganic analytes are outlined in Table B-1 of the QAPjP The analyses for indicator parameters are non-CLP Non-CLP analyses will be conducted according to SW-846 (EPA, 1990) The precision criteria for these samples are specified in the respective methods

5 4 Sensitivity

Sensitivity defines the lowest concentration (detection limit) that a method can accurately and repeatedly detect for a particular chemical or compound The required detection limits for CLP analyses are outlined in Table B-1 of Appendix B in the QAPjP (EG&G 1992b) Detection limits for non-CLP indicator parameter analyses shall be those specified in the respective EPA methods

5 5 Representativeness

Representativeness is a qualitative measure of data quality defined by the degree to which the data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or in this case, an environmental condition Representativeness is ensured through the careful development and review of the sampling strategy outlined in the FSP and SOPs for sample collection, analysis and field data collection

5 6 Data Comparability

Comparability is a qualitative measure defined by the confidence with which one data set can be compared to another Differences in field and laboratory procedures greatly affect comparability Comparability is ensured by implementation of the FSP, standardized analytical protocols, SOPs for field investigations, and by reporting data in uniform units

5 7 Completeness

Completeness is a quantitative measure of data quality expressed as the percentage of valid or acceptable data obtained from a measurement system (EG&G 1992c) The target completeness objective for both field and analytical data for this project is 90 percent

5 8 Sample Management

Good sample management is a critical component of the OU 11 investigation It ensures that sample integrity is maintained from sampling through analysis Sample management, including labelling, sampling, decontamination, preservation/storage, chain of custody and shipping will be conducted in accordance with applicable SOPs, unless otherwise modified as necessary Table 5-2 lists the types of containers, preservation and holding times for samples and/or sample suites for each media

5 9 Data Reporting

Field data will be collected and reported as outlined in SOP FO 14, Field Data Management Laboratory data from the 24-hour turnaround samples will be reported in a facsimile transmittal to the on-site manager and EG&G personnel or their designees, in order to facilitate decision making for the observational sampling approach An electronic transmittal, in the Rocky Flats Environmental Database System (RFEDS) format, will subsequently be sent to EG&G or their designees for input into the OU 11 database The EPA CLP sample results will be reported as specified in the GRRASP and the RFP "Specifications for Providing the Electronic Deliverable Lab Data to the Rocky Flats Environmental Data Management System (EG&G 1991) "

Table 5-1
Field QA/QC Sample Collection Frequency

Activity	Frequency
Field Duplicate[1]	1 in 10
Field Preservation Blanks	1 sample per shipping container (or a minimum of 1 per 20 samples)
Equipment Rinsate Blank	1 in 20 or 1 per day
Triplicate Samples (benthic samples) [3]	For each sampling site [2]
Source Water Blanks	1 sample per source
Trip Blanks[4]	1 in 20

1 For samples to be analyzed for inorganics
2 One equipment rinsate blank in twenty samples or one per day whichever is more frequent for each specific sample matrix being collected when non-dedicated equipment is being used
3 For samples collected for tissue analysis
4 Organics sampling

TABLE 5-2
SAMPLE CONTAINERS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES FOR OU 11 SAMPLES

MATRIX	PARAMETER	CONTAINER	PRESERVATIVE	HOLDING TIME
SOIL	TAL Metals	1X8 oz wide-mouth glass jar	none	6 months (28 days for mercury)
	Nitrates	8 oz wide mouth glass with Teflon®-lined	none	As Soon As Possible
	TCL Volatiles	1 X 125 ml wide-mouth Teflon lined jar	Cool, 4 degrees C out of sunlight	7 days
	TCL Semivolatiles	1 X 250 ml wide-mouth Teflon-lined jar	Cool, 4 degrees C out of sunlight	7 days until extraction, 40 days after extraction
	Radionuclides	500 mL wide-mouth glass jar	none	none
WATER	TCL Volatiles	40 ml amber glass bottle with TFE silicon septa	Cool, 4 degrees C, out of sunlight	7 days
	TCL Semivolatiles	1 liter amber glass bottle with Teflon lined closure	Cool, 4 degrees C, out of sunlight	7 days until extraction, 40 days after
	Nitrate/Nitrite	2 L/P, glass	1 1 Sulfuric Acid, pH<2, Cool, 4 degrees C	28 days
	Radionuclides	3 X 4 L plastic containers (for full suite)	HNO_3	6 months
	TAL Metals	1 X 1 L polyethylene bottle	nitric acid pH<2	6 months

APPENDIX A

SUMMARY OF LIQUID SAMPLING RESULTS FOR THE SOLAR EVAPORATION PONDS

Table A-1
SUMMARY OF LIQUID SAMPLING RESULTS FOR THE
SOLAR EVAPORATION PONDS

COMPOUND	UNITS	207 B NORTH 1984-1988 Range	207 B CENTER 1984-1988 Range
ANIONS			
Ammonia	ppm	NA	NA
Bicarbonate	ppm	NA	NA
Carbonate	ppm	NA	NA
Chloride	ppm	NA	NA
Cyanide, Total	ppm	NA	NA
Fluoride	ppm	NA	NA
Nitrate, N	ppm	212-1367	ND-1220
Nitrite	ppm	NA	NA
Phosphate, Ortho	ppm	NA	NA
Phosphate, Total	ppm	NA	NA
Sulfate	ppm	NA	NA
Sulfide	ppm	NA	NA
TKN-N	ppm	NA	NA
RADIONUCLIDES			
Americium-241	pCi/l	ND	NA
Plutonium-239	pCi/l	ND	NA
Uranium-234	pCi/l	50-53	NA
Uranium-235	pCi/l	NA	NA
Uranium-238	pCi/l	31-33	NA
Uranium	pCi/l	NA	NA
Tritium	pCi/l	1200-1300	NA
METALS			
Aluminum	ppm	ND-1 00	ND-2 00
Antimony	ppm	ND	ND
Arsenic	ppm	ND	ND
Barium	ppm	ND-0 22	ND
Beryllium	ppm	ND-0 06	ND
Bismuth	ppm	ND	ND
Boron	ppm	0 09-0 31	0 071-0 67
Cadmium	ppm	ND-0 01	ND-0 01
Calcium	ppm	20-290	2 9-95
Cerium	ppm	ND	ND
Cesium	ppm	ND	ND-0 35
Cobalt	ppm	ND	ND

NA = Not Analyzed
ND = Not Detected (below detection limits)
ppm = parts per million

Table A-1
SUMMARY OF LIQUID SAMPLING RESULTS FOR THE
SOLAR EVAPORATION PONDS

COMPOUND	UNITS	207 B NORTH	207 B CENTER
		1984-1988 Range	1984-1988 Range
Chromium, Total	ppm	ND	ND
Chromium, Hexavalent	ppm	NA	NA
Copper	ppm	ND	ND-0 037
Germanium	ppm	ND	ND
Iron	ppm	ND-0 29	ND-0.2
Lead	ppm	ND-0 004	ND-0 002
Lithium	ppm	0 37-6	0 052-3 5
Magnesium	ppm	66-120	3 9-91
Manganese	ppm	ND-0 015	ND-0 022
Mercury	ppm	ND	ND
Molybdenum	ppm	ND-0 0069	0 004-0 037
Nickel	ppm	ND-0 05	ND-0 016
Niobium	ppm	ND	ND
Phosphorous	ppm	ND	ND-0 2
Potassium	ppm	56-120	30-110
Rubidium	ppm	ND	ND
Selenium	ppm	ND-0 024	ND-0 019
Silicon	ppm	ND-5 6	1 4-5 5
Silver	ppm	ND-0 082	ND-0 015
Sodium	ppm	363-820	67-800
Strontium	ppm	0 14-3 5	0 14-0 52
Tantalum	ppm	ND	ND
Tellurium	ppm	ND	ND
Thallium	ppm	ND	ND
Thorium	ppm	ND	ND
Tin	ppm	ND	ND
Titanium	ppm	ND	ND
Tungsten	ppm	ND	ND
Vanadium	ppm	ND	ND-0 0081
Zirconium	ppm	ND	ND-0 004
Zinc	ppm	ND-0 022	ND-0 041

NA = Not Analyzed
ND = Not Detected (below detection limits)
ppm = parts per million

APPENDIX B

MATHEMATICAL ANALYTICAL MODEL

West Spray Field, Rocky Flats Plant

Project Objective

The objective of this groundwater project is to evaluate the influence of spray application on the water table underlying the West Spray Field of Rocky Flats Plant (RFP) This paper presents an analytical two dimensional model which has been applied to the West Spray Field parameters

Background

For a period of approximately 4 1/2 years, from April, 1982 to October, 1985, spray irrigation was employed to evaporate RFP waste water The West Spray Field, which was identified as a RCRA hazardous waste management unit in 1986, includes an area of approximately 105 acres Initially, application was performed using two moving irrigation lines mounted on metal wheels, later these portable lines were replaced by fixed lines

Three areas received irrigation The location and size of the three areas as well as the approximate location of the fixed lines are shown in Figure 1-1 in Section 1 of this Technical Memorandum According to recent estimates, approximately 66,000,000 gallons of waste water were applied at variable rates of 0 to 450 gallons per minute The width of each spray line was 80 feet

Geologic/Hydrogeologic Setting

The West Spray Field is situated on top of the Rocky Flats Alluvium unconfined aquifer This heterogeneous alluvial fan deposit is composed of gravel, sand, and clay layers and lenses The overall thickness of the formation in the West Spray Field area is approximately 70 feet, and the average depth to water is approximately 50 feet However, historical and recent drilling data in the West Spray Field area have revealed that one or more perched water layers are present This study will model the configuration of one such perched mound

The Rocky Flats Alluvium has been pump tested in other areas of Rocky Flats. Hydraulic conductivities from those tests were assumed to be representative and were used in the analytical model

Analytical Model

The analytical model was derived from a paper entitled "Hydrodynamics of Perched Mounds", (Brock 1976) in which models for transient and steady state mound development are presented Equations for three basin shapes strip, circular, and square, are given, equations representing the strip basin steady state solution were applied to the West Spray Field Area 1. The physical model consists of a shallow subsurface groundwater mound developing on top of a clay layer within the Rocky Flats Alluvium aquifer

Hydrologic Assumptions

The following assumptions are inherent to the analytical solutions

1 Only saturated flow occurs within the perched mound

2 The material above the semipervious layer is homogeneous and isotropic

3 The pressure distribution is hydrostatic within the perched mound

4 The pressure is atmospheric just below the semipervious layer

5 Recharge to the aquifer was applied uniformly and at a constant rate over the recharge basin

Analytical Solution Equations

Although there is no exact analytical solution for the steady state model presented by Brock, there is a close approximation consisting of five equations Solving the equations yields values of the maximum height and lateral extent of the mound for a set of input parameters The five equations and definition of symbols are presented below eq 1) $a = (p_0' - K_L') - (K_L'/b')H_0'$

a is calculated in terms of H_0' and substituted into equation 2.

eq 2) $(H_0'^2 - a)^{3/2} + 3/2\ b'\ (H_0'^2 - a) = 3/2\ (b'/K_L')\ a^2$

The value of H_0' is found and substituted into equation 3

eq 3) $H'^2 = H_0'^2 - a\ x'^2$

Equation 3 is solved for $H' = H_1'$, $x' = x/L = 1$

eq 4) $H' = 1/6\ (K_L'/b')\ (c - x')^2 - (3/2)\ b'$

The value of H_1' determined in equation 3 and the value of $x' = 1$ are used in equation 4 to determine a value for c

eq 5) $x'_{max} = c - 3\ (b'/K_L')^{1/2}$

Equation 5 yields x'_{max} With H_0' and c known, H' versus x' can be found

Definition of Terms

b = thickness of semipervious layer, $b' - b/L$
H = thickness of mound, $H' = H/L$
H_0 = H at center of basin, $H_0' = H_0/L$ at $X' = 0$
H_1 = H at edge of basin, $H_1' = H_1/L$ at $x' = 1$
K = permeability above layer
K_L = permeability of layer, $K_L' = K_L/K$
L = half width of strip basin
p_0 = recharge rate for $x < L$ (volume/time/area)
x = distance from center of strip, $x' = x/L$
x'_{max} = x' at which H' = o or dimensionless length of mound

Parameters Used

K = 445 ft /day
K_L = 004 ft./day
b = 2 5 feet
L = 400 feet
p_0 = 015 $ft^3/day/ft^2$

p_0 was estimated using the following information

Total volume of water applied = 66,000,000 gal.

Total days applied = 547.5 (It was assumed that during the 4 1/2 years irrigation was practiced, water was applied 1/3 of the time)

Using the information above, the average P_0 was calculated to be 0102 ft./day. However the equations were yielding invalid results when this low rate was used. By trial and error, it was determined that P_0 = .015 ft./day was the lowest rate that could be entered to the equations if the other parameters were held constant P_0 = .015 ft./day was considered to be a reasonable average infiltration rate and was used

Calculated Results

H_0 = 6 80 feet H_0' = 01699

H_1 = 0.97 feet H_1' = 002430

x_{max} = 409 6 feet x'_{max} = 1 024

a = 0002828

c = 1 2219

Values for the construction of a two dimensional mound profile were calculated, the mound cross sectional profile is attached (Figure A-1) The line of section for the mound is also shown on the map of the West Spray Field in Figure 3-2 in Section 3 of this Technical Memorandum

Discussion of Results

The above results were calculated using assumed values for K, K_L, b, and P_0 According to this analysis, the maximum height of subsurface groundwater mound development at steady state is 6 8 feet Two numerical analyses, one for steady state flow and one for transient flow, yielded similar results in terms of mound thickness However in the numerical analyses, the effect of varying K and b values were also investigated In addition, the transient numerical model included the entire West Spray Field rather than only Area 1 The significance of these studies in light of the field sampling plan is that subsurface groundwater mounds under the West Spray Field are relatively thin Good core recovery is critical to the characterization program

Figure B-1 East-West Profile of Mound Across Area 1

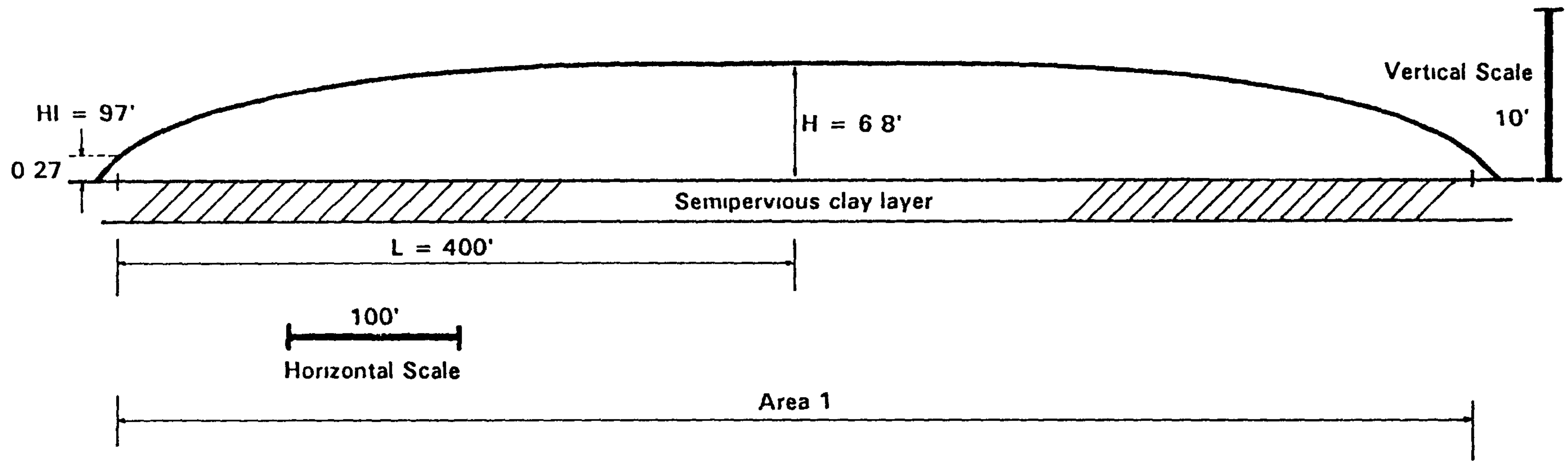


TABLE B-1 CALCULATED EAST-WEST PROFILE OF MOUND ACROSS AREA 1

Data Calculated for Mound Profile

x	x'	H'	H
(H_0)	0	.01699	6.80
50'	.125	.01686	6.74'
100'	.25	.01646	6.58'
150'	.375	.01578	6.31'
200'	.5	.01476	5.90'
250'	.625	.01334	5.34'
300'	75	.01138	4.55'
350'	.875	.00849	3.40'
400' (H_1)	1 0	.002421	0.97
409 6' x_{max}			0

APPENDIX C

SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES

TABLE C-1
SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES
ALLUVIAL GROUNDWATER

Analytes	Units	Sample Type	Sample No	Max Detected Value	Sample Mean	Background Mean
Metals						
Aluminum	µg/L	Total	46	208,000 00	11,237 99	6,239.42
Iron	µg/L	Total	46	198,000 00	10,692 18	8,215 92
Manganese	µg/L	Total	46	2,710 00	256 33	165 77
Sodium	µg/L	Total	46	21,200 00	13,457 83	7,547 90
Antimony	µg/L	Total	46	17 20	11 28	21 15
Arsenic	µg/L	Total	45	1.80	1 29	1 20
Barium	µg/L	Total	46	1,040 00	108 82	123 20
Beryllium	µg/L	Total	46	16 40	1 33	0.82
Cadmium	µg/L	Total	46	1 30	1 24	1.22
Calcium	µg/L	Total	46	62,200 00	23,390 22	34,036 84
Chromium	µg/L	Total	46	208 00	14 04	14 43
Cobalt	µg/L	Total	46	68 00	7 04	5 02
Copper	µg/L	Total	46	191 00	11 15	12 49
Lead	µg/L	Total	46	59 80	4 57	6 58
Lithium	µg/L	Total	46	134 00	12 97	8 79
Magnesium	µg/L	Total	46	37,000 00	6,156 93	5,295 26
Molybdenum	µg/L	Total	46	3 80	15 02	2 90
Nickel	µg/L	Total	46	155 00	15 46	14 16
Potassium	µg/L	Total	46	25,200 00	2,045 11	1,455 35
Silicon	µg/L	Total	33	135,000 00	23,336 36	13,100 00
Silver	µg/L	Total	46	9 40	1 87	1 73
Strontium	µg/L	Total	45	252 00	126 96	133 54
Thallium	µg/L	Total	46	1 00	1 15	0 65
Tin	µg/L	Total	46	39 40	23 26	11 64
Vanadium	µg/L	Total	46	349 00	21 28	17 29
Zinc	µg/L	Total	46	405 00	32 29	64 73
Aluminum	µg/L	Dissolved	42	1,030 00	64 02	201 92
Antimony	µg/L	Dissolved	46	26 30	12 71	15 33
Barium	µg/L	Dissolved	46	87 20	51 05	68 01
Calcium	µg/L	Dissolved	46	39,400 00	21,841 96	32,205 60
Chromium	µg/L	Dissolved	46	3 10	2 22	4 78
Cobalt	µg/L	Dissolved	46	6 50	4 83	3 94
Copper	µg/L	Dissolved	46	2 30	2 73	4 05
Iron	µg/L	Dissolved	43	1,730 00	105 30	221 75
Lead	µg/L	Dissolved	46	1 50	0 81	1 58
Lithium	µg/L	Dissolved	45	7 10	8 94	7 64
Magnesium	µg/L	Dissolved	46	9,820 00	4,469 57	4,102 23
Manganese	µg/L	Dissolved	46	1,380 00	88 67	7 59

NOTE

The calculated sample mean incorporates each non detect as a value equal tohalf the detection limit For compounds having high detection limits the value of the mean may exceed the maximum detected value

TABLE C-1
SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES
ALLUVIAL GROUNDWATER

Analytes	Units	Sample Type	Sample No	Max Detected Value	Sample Mean	Background Mean
Mercury	µg/L	Dissolved	46	0.24	0 11	0 10
Nickel	µg/L	Dissolved	46	5 70	5 31	6 33
Potassium	µg/L	Dissolved	46	1,360.00	773 15	657 27
Selenium	µg/L	Dissolved	46	1 60	0 85	16 06
Silicon	µg/L	Dissolved	33	14,300.00	10,838 79	8,614 58
Sodium	µg/L	Dissolved	46	20,800 00	13,124 57	7,611 54
Strontium	µg/L	Dissolved	46	236 00	122 88	265 56
Tin	µg/L	Dissolved	46	11 20	22 24	19 04
Vanadium	µg/L	Dissolved	45	3 90	4 97	5 10
Zinc	µg/L	Dissolved	46	19 10	4 69	17 48
Mercury	µg/L	Total	46	0 24	0 11	0 11
Selenium	µg/L	Total	45	1 00	0 86	1 00
Arsenic	µg/L	Dissolved	46	0 80	1 22	1 06
Radionuclides						
Gross Alpha	pCi/L	Dissolved	42	14 88	1 28	0 60
Uranium-233,234	pCi/L	Dissolved	38	7 74	0 57	0 18
Uranium-238	pCi/L	Dissolved	38	6 76	0 44	0 13
Gross Beta	pCi/L	Dissolved	46	6 96	1 75	1 83
Strontium-89,90	pCi/L	Dissolved	46	1 30	0 34	0 26
Uranium-235	pCi/L	Dissolved	38	0 28	0 04	0 03
Americium-241	pCi/L	Total	42	0 16	0 01	0 00
Cesium-137	pCi/L	Total	31	0 86	0 09	0 13
Plutonium-239,240	pCi/L	Total	41	0 25	0 01	0 00
Tritium	pCi/L	Total	46	1,535 00	146 39	362 50
WQ Parameters						
Chloride	mg/L		35	15 00	7 50	5 24
Fluoride	mg/L		46	2 50	0 55	0 77
Nitrate/Nitrite	mg/L		46	7 30	1 69	1 51
Sulfate	mg/L		46	35 60	11 89	24 17
Cyanide	mg/L		42	0 00	0 00	0 01

NOTE

The calculated sample mean incorporates each non detect as a value equal tohalf the detection limit For compounds having high detection limits the value of the mean may exceed the maximum detected value

TABLE C-2

SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES

BEDROCK GROUNDWATER

Analytes	Units	Sample Type	Sample No	Max Detected Value	Sample Mean	Background Mean
Metals						
Barium	µg/L	Total	8	289 00	167 50	374 87
Chromium	µg/L	Total	8	41 30	25 35	272 23
Aluminum	µg/L	Total	8	15,300 00	5,852 48	2,546 67
Arsenic	µg/L	Total	8	3 60	1 88	4 60
Cadmium	µg/L	Total	8	1 10	1 16	287 97
Calcium	µg/L	Total	8	67,000 00	36,737 50	34,583 33
Cobalt	µg/L	Total	8	10 30	4 38	273 02
copper	µg/L	Total	8	20 00	7 91	300 06
Iron	µg/L	Total	8	14,000 00	6,278 00	3,619 13
Lead	µg/L	Total	8	15 00	5 06	5.38
Lithium	µg/L	Total	8	26 60	16 74	46 83
Magnesium	µg/L	Total	8	11,100 00	6,997 50	6,945 00
Manganese	µg/L	Total	8	331 00	170 25	179 23
Molybdenum	µg/L	Total	8	53 10	28 03	276 14
Nickel	µg/L	Total	8	40 10	23 11	285 58
Potassium	µg/L	Total	8	5,060 00	4,170 00	3,216 67
Selenium	µg/L	Total	8	1 30	0 76	1 08
Silicon	µg/L	Total	8	38,400 00	18,300 00	8,905 00
Sodium	µg/L	Total	8	44,800 00	29,400 00	172,350 00
Strontium	µg/L	Total	8	484 00	369 88	420 50
Tin	µg/L	Total	8	15 20	12 13	20 38
Vanadium	µg/L	Total	8	63 30	26 44	288 32
Zinc	µg/L	Total	8	84 50	35 94	368 88
Aluminum	µg/L	Dissolved	8	31 80	14 46	42 16
Antimony	µg/L	Dissolved	8	10 00	9 55	14 97
Arsenic	µg/L	Dissolved	8	2 20	1 48	3 56
Barium	µg/L	Dissolved	8	144 00	88 40	68 17
Calsium	µg/L	Dissolved	7	33,300 00	28,187 50	33,752 63
Cesium	µg/L	Dissolved	8	30 00	83 57	88 34
Iron	µg/L	Dissolved	8	210 00	35 06	26 08
Lithium	µg/L	Dissolved	8	26 30	11 84	49 11
Magnesium	µg/L	Dissolved	8	7,790 00	3,808 00	6,276 32
Manganese	µg/L	Dissolved	8	171 00	54 21	8 40
Molybdenum	µg/L	Dissolved	8	52 70	27 41	18 15
Potassium	µg/L	Dissolved	8	4,230 00	3,000 00	3,379 74
Selenium	µg/L	Dissolved	8	1 20	0 68	1 97
Silicon	µg/L	Dissolved	8	4,470 00	3,835 00	3,536 67
Sodium	µg/L	Dissolved	8	44,800 00	29,525 00	194,115 79

NOTE

The calculated sample mean incorporates each non detect as a value equal to half the detection limit For compounds having high detection limits, the value of the mean may exceed the maximum detected value

TABLE C-2

SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES

BEDROCK GROUNDWATER

Analytes	Units	Sample Type	Sample No	Max Detected Value	Sample Mean	Background Mean
Strontium	µg/L	Dissolved	8	462 00	313 38	450 40
Thallium	µg/L	Dissolved	8	1 00	0 78	1 37
vanadium	µg/L	Dissolved	8	25 00	13 04	7 47
Zinc	µg/L	Dissolved	8	4 30	2 73	11 88
Radionuclides						
Gross Alpha	pCi/L	Dissolved	7	2 60	1 49	3 37
Gross Beta	pCi/L	Dissolved	8	4 47	3 37	4 02
Radium-226	pCi/L	Dissolved	2	0 30	0.23	2 98
Strontium-89, 90	pCi/L	Dissolved	8	1 09	0 43	0 38
Uranium-233, 234	pCi/L	Dissolved	6	1 50	0 47	1 83
Uranium-235	pCi/L	Dissolved	6	0 18	0 06	0 05
Uranium-238	pCi/L	Dissolved	6	1 10	0 30	0 57
Americium-241	pCi/L	Total	7	0 01	0 00	0 01
Cesium-137	pCi/L	Total	5	0 58	0 23	0 00
Plutonium-239, 240	pCi/L	Total	6	0 03	0 01	0 00
Tritium	pCi/L	Total	8	352 60	123 51	400 00
WQ Parameters						
Chloride	mg/L		7	13 00	6 43	103 03
Fluoride	mg/L		8	1 40	1 05	1 20
Nitrate/Nitrite	mg/L		8	0 03	0 02	1 21
Sulfate	mg/L		8	128 00	56 69	203 88

NOTE.

The calculated sample mean incorporates each non detect as a value equal to half the detection limit For compounds having high detection limits the value of the mean may exceed the maximum detected value

TABLE C-3
SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES
SURFACE WATER

Analytes	Units	Sample Type	Sample Number	Max Detected Value	Sample Mean
Metals					
Sodium	µg/L	Total	8	28,900 00	18,070 00
Aluminum	µg/L	Total	8	2,080 00	738 50
Arsenic	µg/L	Total	8	7 80	3 39
Barium	µg/L	Total	8	130 00	70 39
Calcium	µg/L	Total	8	23,000 00	12,032 50
Cesium	µg/L	Total	7	60 00	305 00
Chromium	µg/L	Total	8	4 30	3 78
Cobalt	µg/L	Total	7	9 00	12 83
Copper	µg/L	Total	7	11 60	8 83
Iron	µg/L	Total	8	3,900 00	1,167 00
Lead	µg/L	Total	8	6 00	5 60
Lithium	µg/L	Total	7	2 10	30 30
Magnesium	µg/L	Total	8	6,100 00	2,681 25
Manganese	µg/L	Total	8	830 00	141 64
Mercury	µg/L	Total	7	0 37	0 14
Nickel	µg/L	Total	7	10 40	12 32
Potassium	µg/L	Total	8	3,900 00	4,615 00
Selenium	µg/L	Total	8	2 80	2 01
Silicon	µg/L	Total	1	6,310 00	6,310 00
Silver	µg/L	Total	7	4 40	3 75
Strontium	µg/L	Total	7	160 00	319 13
Vanadium	µg/L	Total	7	4 90	12 23
Zinc	µg/L	Total	8	118 00	45 75
Sodium	µg/L	Dissolved	8	29,700 00	18,550 00
Aluminum	µg/L	Dissolved	8	935 00	421 40
Antimony	µg/L	Dissolved	8	12 00	17 60
Arsenic	µg/L	Dissolved	8	6 20	3 30
Barium	µg/L	Dissolved	8	130 00	66 90
Calcium	µg/L	Dissolved	8	26,000 00	12,132 50
Chromium	µg/L	Dissolved	7	3 10	3 60
Cobalt	µg/L	Dissolved	7	11 00	12 90
Copper	µg/L	Dissolved	8	27 00	9 90
Iron	µg/L	Dissolved	8	1,100 00	504 60
Lead	µg/L	Dissolved	8	2 70	4 50
Lithium	µg/L	Dissolved	8	2 60	32 80
Magnesium	µg/L	Dissolved	8	7,000 00	2,765 00
Manganese	µg/L	Dissolved	8	780 00	117 10
Mercury	µg/L	Dissolved	8	0 23	0 12

NOTE
The calculated sample mean incorporates each non detect as a value equal to half the detection limit For compounds having high detection limits, the value of the mean may exceed the maximum detected value

TABLE C-3
SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES
SURFACE WATER

Analytes	Units	Sample Type	Sample Number	Max Detected Value	Sample Mean
Molybdenum	µg/L	Dissolved	8	3 00	36 00
Nickel	µg/L	Dissolved	8	6 10	11 50
Potassium	µg/L	Dissolved	8	13,000 00	5,332 50
Silicon	µg/L	Dissolved	1	5,870 00	5,870 00
Strontium	µg/L	Dissolved	8	180 00	343 60
Vanadium	µg/L	Dissolved	7	3 70	12 00
Zinc	µg/L	Dissolved	8	68 30	28 20
Radionuclides					
Gross Alpha	pC/L	Dissolved	1	1 15	1 15
Gross Beta	pC/L	Dissolved	1	12 53	12 53
Strontium-89, 90	pC/L	Dissolved	1	1 44	1 44
Uranium-233, 234	pC/L	Dissolved	1	0 26	0 26
Uranium-235	pC/L	Dissolved	1	0 05	0 05
Uranium-238	pC/L	Dissolved	1	0 21	0 21
Americium-241	pC/L	Total	4	0 01	0 00
Cesium-137	pC/L	Total	4	0 54	0 00
Gross Alpha	*pC/L*	*Total*	3	2 52	0 93
Gross Beta	pC/L	Total	3	8 00	6 02
Plutonium-239/240	pC/L	Total	4	0 01	0 01
Strontium-89,90	pC/L	Total	3	0 90	0 56
Tritium	pC/L	Total	2	186 50	123 25
Uranium, total	pC/L	Total	1	0 00	0 00
Uranium-233,234	pC/L	Total	3	0 09	0 05
Uranium-235	pC/L	Total	3	0 00	0 00
Uranium-238	pC/L	Total	3	0 04	0 02

NOTE

The calculated sample mean incorporates each non detect as a value equal to half the detection limit For compounds having high detection limits, the value of the mean may exceed the maximum detected value

TABLE C-4

SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES

SURFACE SOILS

Analytes	Sample Units	Sample Number	Max Detected Value	Sample Mean	Background Mean
Metals					
Lead	mg/kg	12	26 00	16 15	36 02
Mercury	mg/kg	12	NA	0 18	NA
Radionuclides					
Gross Alpha	pCi/g	12	30 00	11 67	10 75
Gross Beta	pCi/g	12	38 00	23 50	33 31
Plutonium - 239/240	pCi/g	12	0 59	0 15	0 05
Uranium - 233, 234	pCi/g	12	1 30	0 93	1 22
Uranium - 238	pCi/g	12	1 40	0 91	1 32
Other					
Nitrate/Nitrite	mg/kg	12	NA	60 00	2 26

NOTE.
The calculated sample mean incorporates each non-detect as a value equal to half the detection limit For compounds having high detection limits, the value of the mean may exceed the maximum detected value

TABLE C-5
SUMMARY STATISTICS AND BACKGROUND COMPARISON FOR OU 11
SUBSURFACE SOILS

Analytes	Sample Units	Sample Number	Max Detected Value	Sample Mean	Background Mean
Metals					
Lead	mg/kg	24	24 00	12 51	8.82
Mercury	mg/kg	22	0 46	0 16	0 18
Radionuclides					
Gross Alpha	pCi/g	24	39 00	12 88	21 82
Gross Beta	pCi/g	23	36 00	24 83	23 89
Plutonium - 239/240	pCi/g	23	0 25	0 03	0 00
Uranium, Total	pCi/g	24	3 00	1 89	1 28
Uranium-233, 234	pCi/g	24	1 60	0 99	0 64
Uranium - 238		24	1 40	0 94	0 63
Other					
Nitrate/Nitrite	mg/kg	22	150 00	36 36	1 08

NOTE.
The calculated sample mean incorporates each non-detect as a value equal to half the detection limit For compounds having high detection limits, the value of the mean may exceed the maximum detected value

APPENDIX D

ECOLOGICAL SAMPLING TABLES

Table D-1

ECOLOGICAL FIELD SAMPLING ACTIVITIES

TAXON	SPRAYED AREAS		NON-SPRAYED AREAS		REFERENCE AREAS		TOTAL SAMPLES	
	PROPOSED	COMPLETED	PROPOSED	COMPLETED	PROPOSED	COMPLETED	PROPOSED	COMPLETED
GRIDS NEEDED (5x5)	4	4	4	4	4	4	**12**	**12**
TERRESTRIAL								
BIOTA								
Vegetation Cover (5/grid)	20	20	20	20	20	20	**60**	**60**
Vegetation Belt Transects (5/grid)	20	20	20	20	20	20	**60**	**60**
Vegetation Quadrats (5/grid)	20	20	20	20	20	20	**60**	**60**
Arthropods (1/grid)	4	4	4	4	4	4	**12**	**12**
Birds (5, 2-ha plots x 6 replicates, 500-m transect)	30 for entire area				30 for area		**60**	**60**
(#of grids x 25 traps x 3 trap nights)	300	300	300	300	300	300	**900**	**900**
Large Mammals								
Pellet Counts	4	0 (a)	4	0 (a)	4	0 (a)	**12**	**0 (a)**
Relative Abundance	1	1	1	1	1	1	**3**	**3**
TISSUE								
grids x 3 replicates, 25-g sample)	12	12	12	12	12	12	**36**	**36**
Small Mammals (1/species/grid)	4	0 (b)	4	0 (b)	4	0 (b)	**12**	**0 (b)**
Arthropods (1, 25-g/site)	1	0 (b)	1	0 (b)	1	0 (b)	**12**	**0 (b)**

Table D-1
ECOLOGICAL FIELD SAMPLING ACTIVITIES

TAXON	SPRAYED AREAS		NON-SPRAYED AREAS		REFERENCE AREAS		TOTAL SAMPLES	
	PROPOSED	COMPLETED	PROPOSED	COMPLETED	PROPOSED	COMPLETED	PROPOSED	COMPLETED
AQUATIC	**Surface Water Pond #128**				**Lindsay Pond**			
BIOTA								
5 replicates per species								
Zoobenthos (quantitative)	1	1						
Zoobenthos (qualitative)	5	0 (c)			5	0 (c)	10	0 (c)
Periphyton	5	0 (c)			5	0 (c)	10	0 (c)
Phytoplankton	5	0 (c)			5	0 (c)	10	0 (c)
Zooplankton	5	0 (c)			5	0 (c)	10	0 (c)
TISSUE								
3 replicates, 25-g sample/taxon								
Periphyton	3	0 (b)			2	0 (b)	5	0 (b)
Macrophyte	3	0 (b)			2	0 (b)	5	0 (b)
Zoobenthos (not expected)	3	0 (b)			2	0 (b)	5	0 (b)
Benthos (3 replicates x 3 species)	9	0 (b)			9	0 (b)	18	0 (b)
REPTILES & AMPHIBIANS								
TISSUE								
5 replicates, 25-g samples								
Anurans	3	0 (b)			3	0 (b)	6	0 (b)
Uropods	3	0 (b)			3	0 (b)	6	0 (b)
CRUSTACEANS								
TISSUE	3	0 (b)			3	0 (b)	6	0 (b)

(a) Scheduled for Spring, 1994

(b) Sample collection depends on preliminary data, problem formulation, and Agency guidance

(c) Preliminary sampling results under EcMP and preliminary exposure assessment indicate that the SW-128 site may not be in the contaminant pathway from OU-11 except perhaps during high flow runoff events Tentatively scheduled for sampling during Spring, 1994

Table D-2
OU 11 DATA FROM THE
ECOLOGICAL MONITORING PROGRAM STUDIES

	SPRAYED AREAS	NON-SPRAYED AREAS	REFERENCE AREAS	TOTAL SAMPLES
TERRESTRIAL				
Soil Invertebrates				
a) Arthropods 0-5 cm	20+4 QA/QC	20+4 QA/QC	20+4 QA/QC	72
b) Arthropods 5-10 cm	20+4 QA/QC	20+4 QA/QC	20+4 QA/QC	72
c) Nematodes 0-5 cm	20+4 QA/QC	20+4 QA/QC	20+4 QA/QC	72
d) Nematodes 5-10 cm	20+4 QA/QC	20+4 QA/QC	20+4 QA/QC	72
Soil Functions	20+4 QA/QC	20+4 QA/QC	20+4 QA/QC	72
Soil Physical/Chemical	20	20	20	60
Plant Tissue	6	6	6	18
Litter	6	6	6	18
AQUATIC				
Emergent Insects	15		29	44
Zoobenthos (qualitative)	1		1	2
Zoobenthos (quantitative)	3		6	9
Phytoplankton	3		10	13
Zooplankton	3		11	14
Water Chemistry	8		10	18

APPENDIX E

STATISTICAL JUSTIFICATION FOR THE REVISED OU 11 SURFACE SOIL SAMPLING PLAN

APPENDIX E
STATISTICAL JUSTIFICATION FOR THE REVISED OU 11 SURFACE SOIL SAMPLING PLAN

Fewer surface soil samples are required for the investigation of potential contamination in OU 11 than were indicated in the originally proposed field sampling plan Analysis of available data, statistical power considerations for comparing site and background means, and the inapplicability of hot spot detection all indicate the need for fewer samples A sampling scheme is recommended which will allow comparisons of spray and channel areas within the WSF The original field sampling plan called for a uniform sampling grid over the entire spray field with 300 foot spacings which resulted in the need for collecting and analyzing 75 soil samples Adequate comparisons to background and additional comparisons within the WSF can be made based on fewer samples

In sampling activities conducted in 1988, 12 test pits were dug and soil samples were collected at three separate depths in each pit Results from the sampling activities were used in conducting a statistical analysis

Nine surface soil samples from the Rock Creek areas were used for background comparisons with the surface soils from the test pits Data were available to support the comparisons of five radionuclide analytes, two metal analytes, and two water quality parameters in soil As shown in the table on the following page and the graphs at the end of this report, none of these seven comparisons resulted in statistically significantly higher values in the site than the Rock Creek background levels

In the table, the column labeled "P-value" indicates whether the site data are elevated relative to the background data P-values range from zero to one with smaller values (typically less than 0 05) indicating elevated site results These P-values were generated using nonparametric rank tests The exceptionally large P-values suggest in several cases that the WSF has lower results than the Rock Creek area

Even though no contamination is indicated, the lack of data on many metals and some radionuclides suggests the need for additional surface soil sampling to support further statistical comparisons Two objectives should influence the level of such sampling activity One is the comparison of site and background data for the determination of contaminants, while the other is the detection of "hot spots" (relatively small areas with significantly greater contamination than their immediate surroundings)

The logic that was applied in determining the need for the originally proposed 300 foot grid was based on power considerations in the site to background comparison objective The following discussion was presented in the original OU 11 field sampling plan

> Based on (U S EPA guidance documents), the number of samples necessary at a site to meet minimum statistical performance standards can be computed based upon the derivation of the coefficient of variation for existing data the calculated coefficient of variation and the assumed minimum statistical performance objectives of confidence (80%), power (90%), and minimum detectable relative difference (20%) are inserted into the following formula for statistical evaluation
>
> $n \geq [(Za + Zb)/D]^2 + 0\ 5(Za)^2$
>
> n = number of samples
> Za = percentile of standard normal distribution for Confidence of 80%
> Zb = similarly defined as Za assuming Power of 90%
> D = minimum relative detectable difference (assume 20%)/CV
> CV = coefficient of variation = Standard Deviation /Arithmetic mean
>
> By employing the 12 test pit results for Plutonium 239, 240, a coefficient of variation of 64% was computed Based upon this value, an estimated minimum of 46 samples would be needed at the WSF site to meet statistical performance standards

This sample size computation of 46 samples to meet power criteria in the comparison of site and background along with a desire to detect hot spots using grid sampling resulted in a grid spacing of 300 feet requiring 75 samples However, with a grid size of 300 feet, to detect an existing hot spot with probability 90, which is typically the standard applied in such statistical methodology, the hot spot would have to have a diameter of approximately 168 feet To attain such detection probability for a smaller hot spot, for example 50 feet, one would have to sample on a grid requiring nearly 1000 soil samples for the WSF

Sampling with the goal of hot spot detection requires a tremendous amount of data to detect even fairly large hot spots In addition, the mechanism of spraying over wide areas does not suggest that hot spots should be of concern in this sampling activity Due to the expectation of little if any contamination, the objective which dictates required sampling levels should be simply the comparison of average analyte levels to background Such comparisons require considerably less data

If areas of potentially greater risk exist, the sampling design should consider these areas to determine if analytes are elevated with respect to other areas within the WSF, as well as with respect to background This could be the case in the WSF with potentially greater contamination risk in either the outflow channels (drainages) or along the spray lines where the bulk of the spray initially came in contact with the soil The 1988 test pits were generally located in the channel areas, and initial comparisons indicate no significantly elevated analytes even in these higher risk areas A stratified surface soil sampling plan will be recommended that allows for the comparison of channel areas, spray areas, and areas that are in neither channels nor spray areas

Since no significant contamination is expected, even in the higher risk areas, the sample size discussion from the original plan is applied to the entire spray field with some modifications The original "80% two-sided confidence level", which results in a one-sided Type I error rate of 0 10 is replaced by a more appropriate Type I error rate of 0 05 With many analyte comparisons to be made, a Type I error rate as high as 0 10 will give an extremely high false alarm rate One out of every 10 analytes which are not elevated will mistakenly be determined to be elevated simply due to sampling variability Reducing the Type I error will help to control the false alarm rate at lower levels This increases required sample sizes relative to the original plan

A major concern with the original plan is the attempt to detect a shift in a mean of 20 (minimum detectable difference) with power 0 90 for small coefficient of variation (CV) values this is not difficult statistically, but for large CV values, this requires huge sample sizes Figure E-1 demonstrates that to statistically determine a difference between the two distributions on the right, which have CV values 0 1, minimal sample sizes are needed The mean, m_2, is ten standard deviations from zero, so a 0 20 shift consists of a shift of two standard deviations Given that the distributions of the sample means cluster around the populations means, m_2 and $m_2 + 2m_2$, the differences in these population means can be easily detected even with samples as small as 2 or 3

The other pair of distributions in Figure E-1 presents a problem The CV is 1 0 - the mean is only one standard deviation from zero Measurements are thus quite close to zero relative to the inherent analytical and sampling variability involved A twenty percent shift in the mean from m_1 to $m_1 + 2m_1$ in this situation is extremely difficult to detect statistically since it represents only one-fifth of a standard deviation Sample sizes would have to be very large to distinguish between these two means Environmental data is often similar, where site data are only marginally, if any, greater than background data, and analytical and sampling variability make small differences even more difficult to detect Considerable cost is incurred in attempting to detect such differences, and the added risk associated with the minimal increase in means is likely of no practical importance

The impact of the CVs on required sample sizes for detecting a specified shift with power 0 90 while maintaining a Type I error of 0 05 is illustrated in Figure E-2 The three lines from top to bottom represent required sample sizes for the respective CVs 1 0, 0 5, and 0 1 The bottom line indicates how only minimal sample sizes are needed to detect such shifts for small CV values For larger CV values, quite large sample sizes are needed to detect shifts less than 4 of the mean Such shifts, as indicated in Figure E-1, are likely of questionable importance

More commonly, shifts are written in terms of the level of variability The desired shift for detection with specified power and Type I error could be taken to be one sigma, or one standard deviation The sample size required would be approximately 10 and would not depend on the CV values However, the "minimum relative detectable difference" would then be function of the CV, and in this one-sigma case, it would be equal to the CV A sample size 10 is required to detect a 0 1 shift in the mean with underlying CV value 0 5, and 1 0 shift with underlying CV value 1 0

For comparison, the detection of a one-half sigma shift would require sample sizes of approximately 36 This corresponds to minimum detectable shifts of 0 5, 0 25, and 0 05 respectively for CV values of 1 0, 0 5, and 0 1 Note that if Figure E-1 were modified to show the 0 5 shift for CV value 1 0 rather than the 0 2 shift, the practicality of detecting that small a shift would still be questionable In addition, consideration of CV values larger than about 0 6 may not be useful for power considerations because, in this type of situation, the underlying distribution generating the data must be non-normal (under normality, the mean is about three standard deviations from the observed minimums, not one standard deviation, as a CV of 1 0 suggests) These power arguments would not hold since either non-parametric approaches or data transformations would be used

To detect reasonable shifts between site and background values with adequate power for the type of CV values encountered in either the original or transformed data, sample sizes of approximately 30 are likely sufficient On Figure E-2, if a horizontal line were drawn from 30 across the graph, the points of intersections would be above the corresponding minimum detectable differences for the 0 90 power level The sample size of 30 gives reasonable detectable differences relative to the CV values To achieve comparable power with nonparametric methods, approximately ten percent more sample values are required

If investigations are to detect reasonably sized hot spots with significant probability, vastly larger sample sizes are required Hot spots are not expected in the WSF due to the way in which potential contamination was dispersed Even though areas of higher risk in the WSF are not thought to be contaminated based on analysis of preliminary data, samples should be selected to support the comparison of these higher risk areas to other areas within the OU

This proposed sampling plan abandons the systematic grid approach for detecting hot spots in favor of specifically locating samples in areas of special interest For the WSF, special interest areas are the discharge channels and spray contact areas (those nearest to the pipes) It is recommended that 11 samples be taken from channels within spray areas, 7 samples be taken from channels outside of spray areas, 10 samples be taken from outside channels in spray areas, and 6 samples be taken from outside of both channels and spray areas This gives a total of 34 samples and provides data on which to base internal OU comparisons even though such comparisons are not expected to detect any differences The actual placement of samples within the various areas could be done randomly, but this approach is not necessary for reasonable inference to be made

Conclusion

Fewer surface soil samples are required for the investigation of potential contamination in WSF than were proposed in the original OU 11 Work Plan Analysis of available data, statistical power considerations for comparing site and background means, and he inapplicability of hot spot detection for the WSF all indicate the need for fewer samples

Table E-1
OU 11 COMPARISON TO BACKGROUND FOR AVAILABLE DATA

Analyte	N Background	% Detect Background	Mean Background	N OU 11	% Detect OU 11	Mean OU 11	P-Value
Gross Alpha	1	100	10 75	12	100	11 67	0 5000
Gross Beta	9	100	33 31	12	100	23 50	0 9768
Plutonium-239,240	9	100	0 05	12	100	0 15	0 9001
Uranium-233/234	7	100	1 22	12	100	0 93	0 9967
Uranium-238	7	100	1 32	12	100	0 91	0 9980
Lead	9	100	36 02	12	100	16 15	0 9999
Mercury	9	0	-	12	8 3	-	-
Nitrate/Nitrite	9	100	2 26	12	8,3	-	0 2445
Total Organic Carbon	3	100	14523 33	12	100	658 33	0 9944

FIGURE E-1

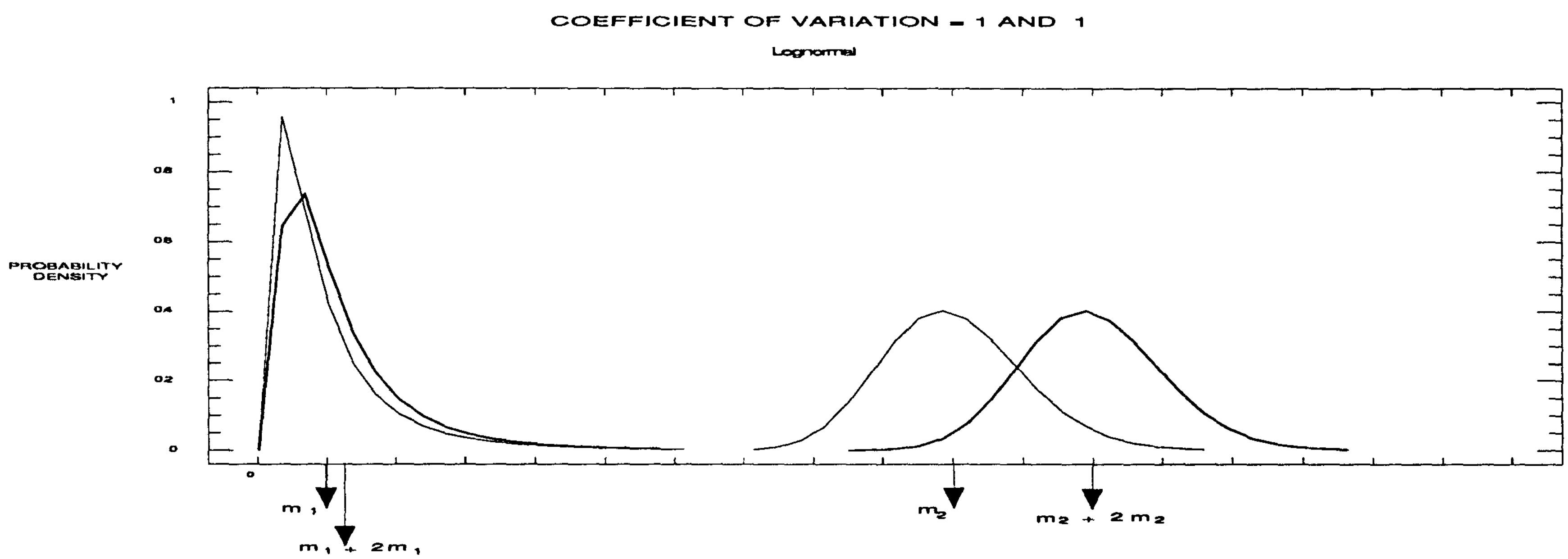
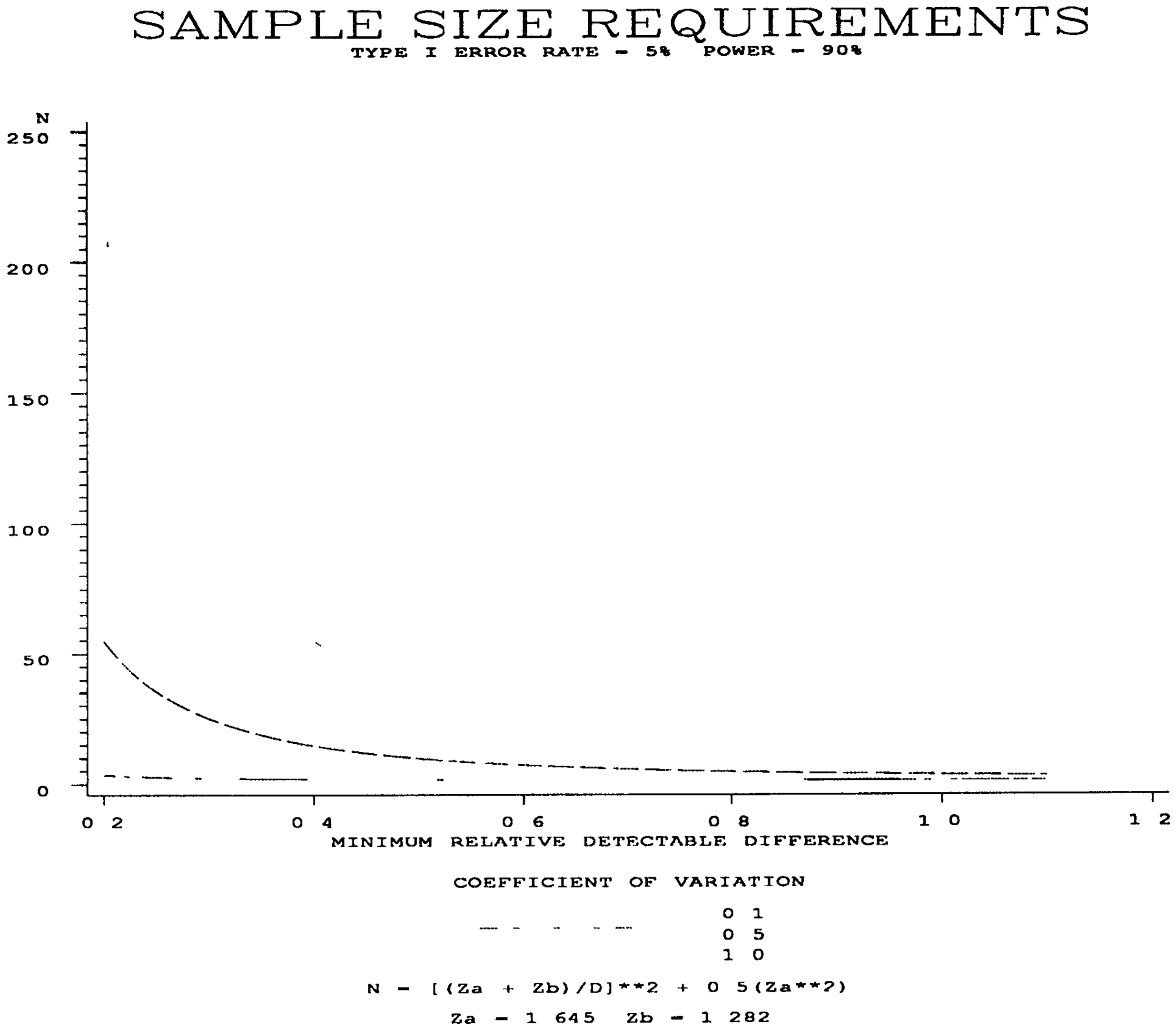

COEFFICIENT OF VARIATION = 1 AND 1
Lognormal
PROBABILITY DENSITY
1
0.8
0.6
0.4
0.2
0
0
m₁
m₁ + 2m₁
m₂
m₂ + 2m₂

FIGURE E-2



SAMPLE SIZE REQUIREMENTS
TYPE I ERROR RATE = 5% POWER = 90%
N
250
200
150
100
50
0
0 2
0 4
0 6
0 8
1 0
1 2
MINIMUM RELATIVE DETECTABLE DIFFERENCE
COEFFICIENT OF VARIATION
0 1
0 5
1 0
N = [(Za + Zb)/D]**2 + 0 5(Za**2)
Za = 1 645 Zb = 1 282

APPENDIX F

TAL METALS
TCL VOLATILES
TCL SEMIVOLATILES

SOIL, SEDIMENT, AND WATER SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

TABLE F-1
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

		Detection Limits*
Target Analyte List - Metals	**Water (μg/l)**	**Soil/Sediment (μg/kg)**
Aluminum	200	40
Antimony	60	12
Arsenic	10	2
Barium	200	40
Beryllium	5	1 0
Cadmium	5	1 0
Calcium	5000	2000
Cesium	1000	200
Chromium	10	2 0
Cobalt	50	10
Copper	25	5 0
Cyanide	10	10
Iron	100	20
Lead	5	1 0
Lithium	100	20
Magnesium	5000	2000
Manganese	15	3 0
Mercury	0 2	0 2
Molybdenum	200	40
Nickel	40	8 0
Potassium	5000	2000
Selenium	5	1 0
Silver	10	2 0
Sodium	5000	2000
Strontium	200	40
Thallium	10	2 0
Tin	200	40
Vanadium	50	10 0
Zinc	20	4 0

TABLE F-2
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

Target Compounds List - Volatiles	Water ($\mu g/l$)	Quantitation Limits* Soil/Sediment ($\mu g/kg$)
Chloromethane	10	10
Bromomethane	10	10
Vinyl Chloride	10**	10
Chloroethane	10	10
Methylene Chloride	5	5
Acetone	10	10
Carbon Disulfide	5	5
1,1-Dichloroethene	5	5
trans 1,2-Dichloroethene	5	5
Chloroform	5	5
1,2-Dichloroethene	5	5
2-Butanone	10	10
1,1,1-Trichloroethane	5	5
Carbon Tetrachloride	5	5
Vinyl Acetate	10	10
Bromodichloromethane	5	5
1,1,2,2-Tetrachloroethane	5	5
1,2-Dichloropropane	5	5
trans-1,3-Dichloropropane	5	5
Trichloroethene	5	5
Dibromochloromethane	5	5
1,1,2-Trichloroethane	5	5
Benzene	5	5
cis-1,3-Dichloropropene	5	5
Bromoform	5	5
2-Hexanone	10	10
4-Methyl-2-penatone	10	10
Tetrachloroethene	5	5
Toluene	5	5
Chlorobenzene	5	5
Ethyl Benzene	5	5
Styrene	5	5
Total Xylenes	5	5

TABLE F-3
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

Semivolatiles	Quantitation Limits* Water (µg/l)	Soil/Sediment (µg/kg)
Phenol	10**	330
bis(2-Chloroethyl)ether	10**	330
2-Chlorophenol	10**	330
1,3-Dichlorobenzene	10	330
1,4-Dichlorobenzene	10	330
Benzyl alcohol	10	330
1,2-Dichlorobenzene	10	330
2-Methylphenol	10	330
bis(2-Chloroisopropyl)ether	10	330
4-Methylphenol	10	330
N-Nitroso-di-n-propylamine	10	330
Hexachloroethane	10	330
Nitrobenzene	10**	330
Isophorone	10	330
2-Nitrophenol	10	330
2,4-Dimethylphenol	10	330
Benzoic acid	50	1600
bis(2-Chloroethoxy)methane	10	330
2,4-Dichlorophenol	10	330
1,2,4-Tricholorobenzene	10	330
Naphthalene	10	330
4-Chloroaniline	10	330
Hexachlorobutadiene	10	330
4-Chloro-3-methylphenol(parachloro-meta-cresol)	10	330
2-Methylnaphthalene	10	330
Hexachlorocyclopentadiene	10	330
2,4,6-Trichlorophenol	10	330
2,4,5-Trichlorophenol	50	1600
2-Chloronapthalene	10	330
2-Nitroaniline	50	1600
Dimethylphthalate	10	330
Acenaphthylene	10	330
2,6-Dinitrotoluene	10	330
3-Nitroaniline	50	1600
Acenaphthene	10	330

TABLE F-3 (continued)
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

Semivolatiles	Water (µg/l)	Quantitation Limits* Soil/Sediment (µg/kg)
2,4-Dinitrophenol	50	1600
4-Nitrophenol	50	1600
Dibenzofuran	10	330
2,4-Dinotrotoluene	10	330
Diethyphthalate	10	330
4-Cholrophenyl-phenyl ether	10	330
Flourene	10	330
4-Nitroaniline	50	1600
4,6-Dinitro-2-methylphenol	50	1600
N-nitrosodiphenylamine	10	330
4,-Bromophenyl-phenylether	10	330
Hexacholobenzene	10**	330
Pentachlorophenol	50	1600
Phenanthrene	10	330
Anthracene	10	330
Di-n-butylphthalate	10	330
Flouranthene	10	330
Pyrene	10	330
Butylbenzylphthalate	10	330
3,3'-Dichlorobenzidine	20**	660
Benzo(a)anthacene	10	330
Chrysene	10	330
bis(2-Ethylhexyl)phthalate	10	330
Di-n-octylphthalate	10	330
Benzo(b)flouranthene	10	330
Benzo(k)flouranthene	10	330
Benzo(a)pyrene	10	330
Ideno(1,2,3-cd)pyrene	10	330
Dibenz(a,h)anthracene	10	330
Benzo(g,h,i)perylene	10	330

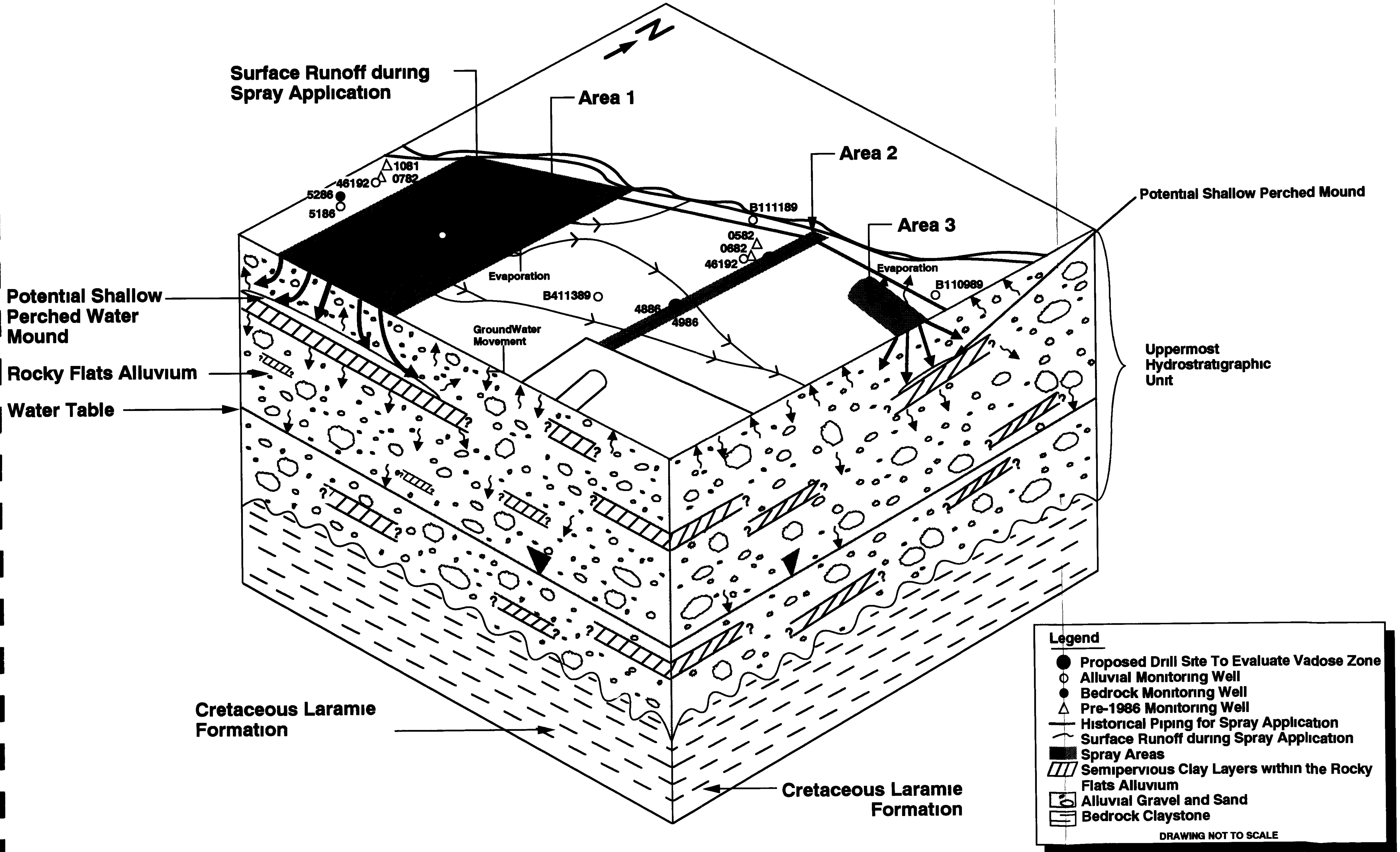
TABLE F-4
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

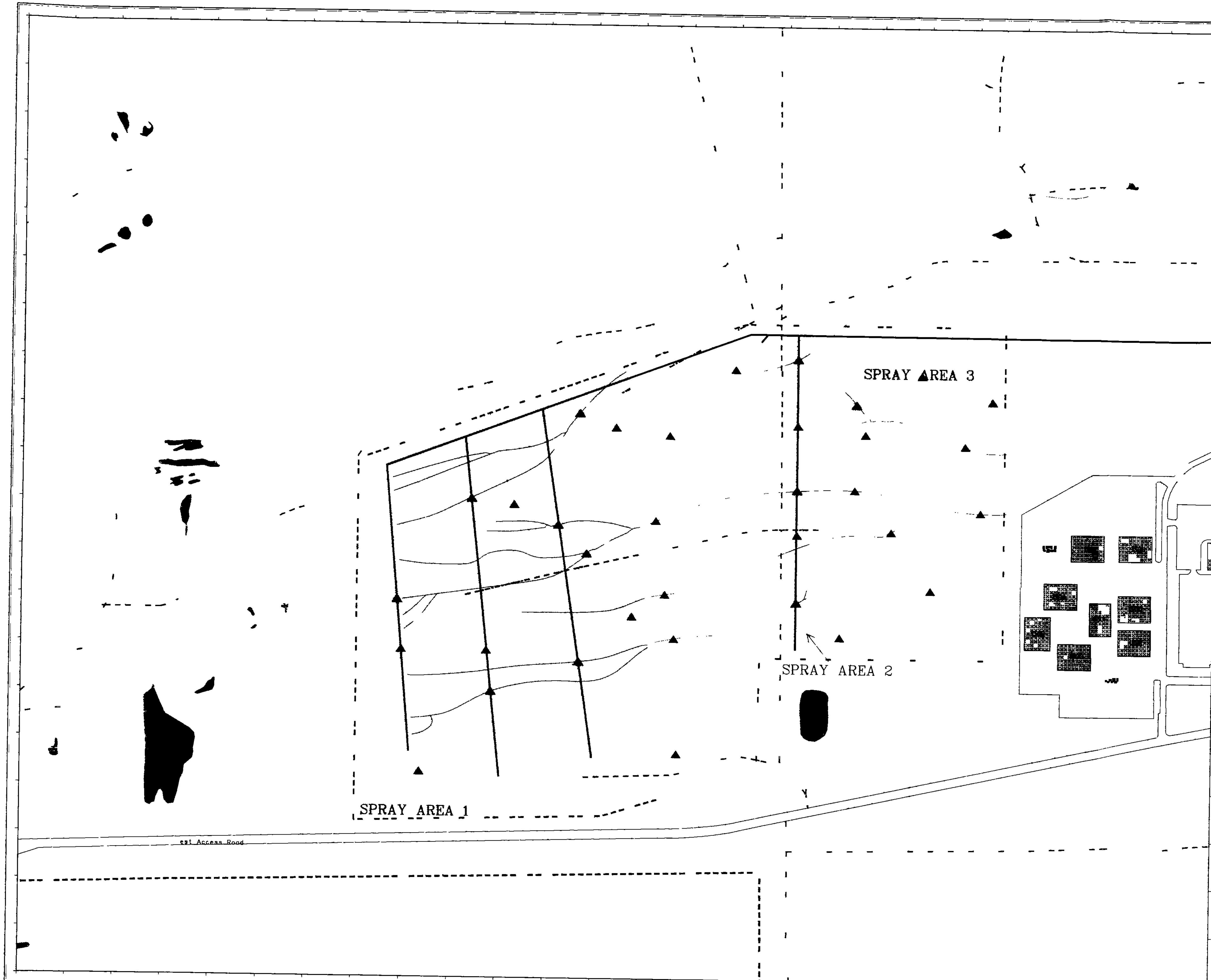
Radionuclides	**Water (pCi/1)**	**Quantitation Limits* Required Detection Limits* Soil/Sediment (pCi/g)**
Gross Alpha	2	4 dry
Gross Beta	4	10 dry
Uranium 233+234, 235 and 238 (each species)	0 6	0 3 dry
Americium 241	0 01	0 02 dry
Plutonium 239+240	0 01	0 03 dry
Tritium	400	400 (pCi/ml)

*Detection and quantitation limits are highly matrix dependent The limits listed here are the minimum achievable under ideal conditions Actual limits may be higher

**The laboratory Practical Quantification Limits (PQLs) for these analytes exceed ARARs

Figure 2-1 Schematic Diagram of Conceptual Model – West Spray Field





OU11/IHSS-168 Basemap
West Spray Field
Proposed Surface Soil
Sample Locations

Figure 4-1

EXPLANATION

- Spray Area
- ▲ Spray and Channel (11)
- ▲ Non-Spray and Channel (7)
- ▲ Spray and Non-Channel (10)
- ▲ Non-Spray and Non-Channel (6)
- IHSS 168 (OU11)
- Piping (Historical)
- Drainag Flow Line

Standard Map Features

- Buildings ther structures
- Lakes and ponds
- Streams, ditches, ther drainage features
- Contours (20' Intervals)
- Fences
- Rocky Flats bo ndary
- Paved roads
- Di roads

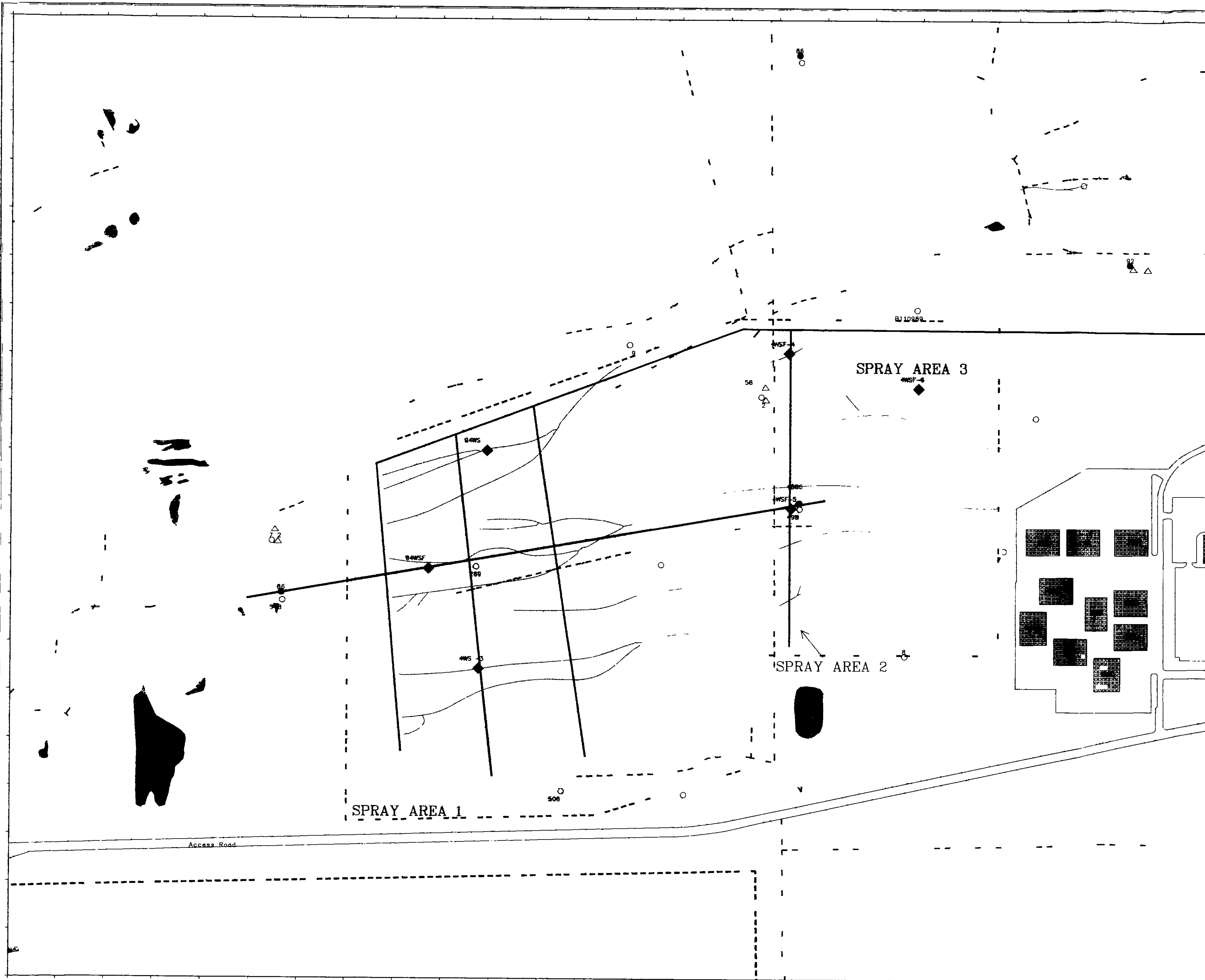
Scale 750
Inch approximately 42 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U S Department of Energy
Rocky Flats Plant

Prepared by
EG&G ROCKY FLATS
Rocky Flats Pla t
P O Bo 464
Golde Colorado 80402-0464

on Ass ned	GIS Analyst		
aft	Checked		
94	Approved		



OU11/IHSS-168 Basemap
West Spray Field
Proposed Monitoring Well Locations

Figure 4-2

EXPLANATION

Spray Area

Proposed Monitoring Wells

△ Pre-1986 Monitoring Wells

● Bedrock Monitoring Wells

○ Alluvial Monitoring Wells

v IHSS 168 (OU11)

Piping (Historical)

Seismic Line

Drainage Flow Line

Standard Map Features

Buildings or other structures

Lakes and ponds

Streams, ditches, other drainage features

Contours (20' Intervals)

Fences

Rocky Flats boundary

Paved roads

Dirt roads

Scale 1 : 750 77
1 inch approximately 42 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum NAD27

U S Department of Energy
Rocky Flats Plant

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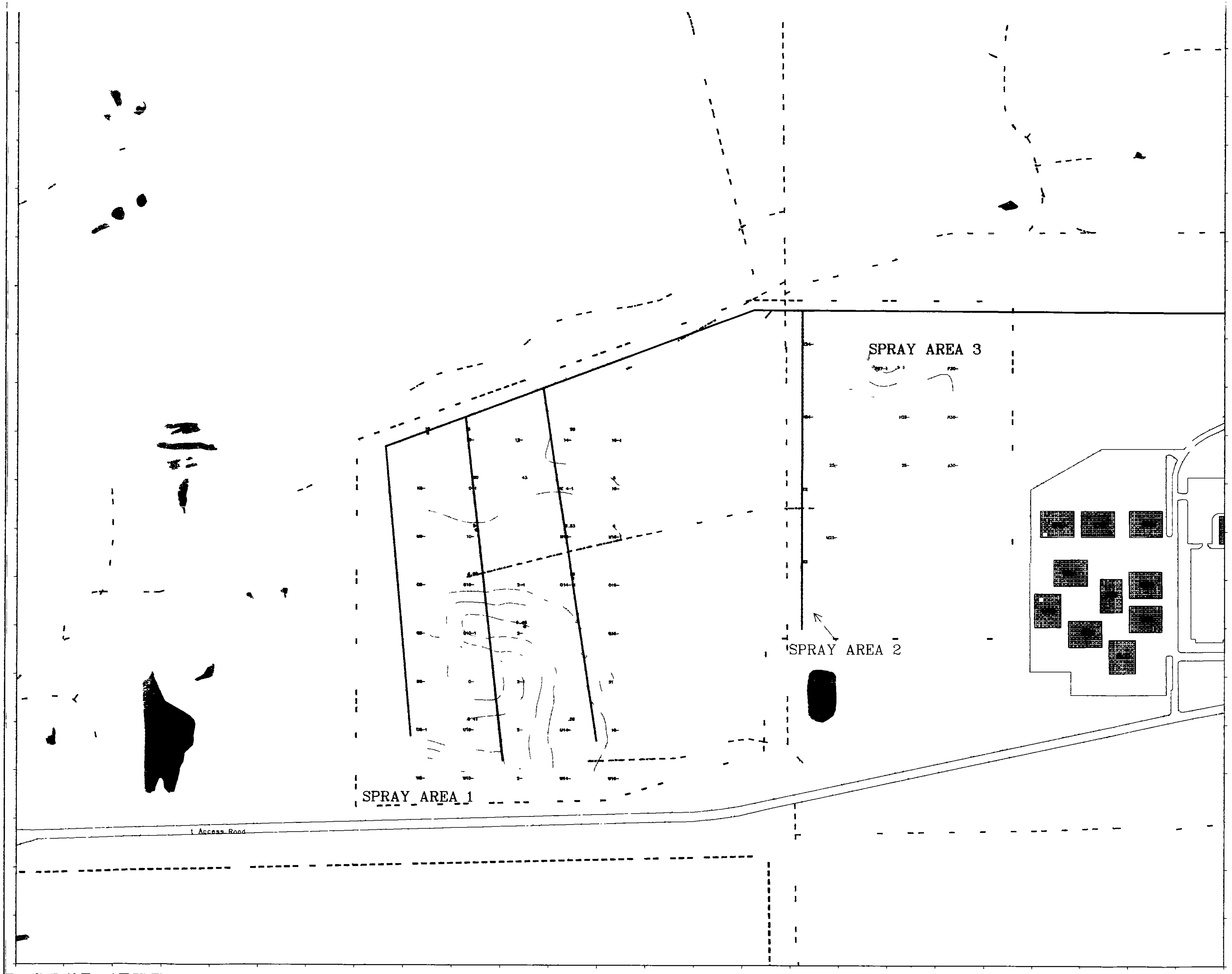
P O Box 464
Golden Colorado 80402-0464

Non Assigned		
eft	Checked	
March 1994	Approved	



West Spray Field (OU11)
HPGE Data Sampling
Total Gamma Exposure Isopleth

Figure 3-4

EXPLANATION

Spray Area

Total Gamma Exposure (uR/h)

HPGE Station ID

IHSS 168 (OU11)

Piping (Historical)

Contour lines

Standard Map Features

Buildings or other structures

Lakes and ponds

Streams, ditches, or other drainage features

Contours (20' intervals)

Fences

Rocky Flats boundary

Paved roads

Dirt roads

Scale 1 : 790
1 inch = approximately 42 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum NAD27

U S Department of Energy
Rocky Flats Plant

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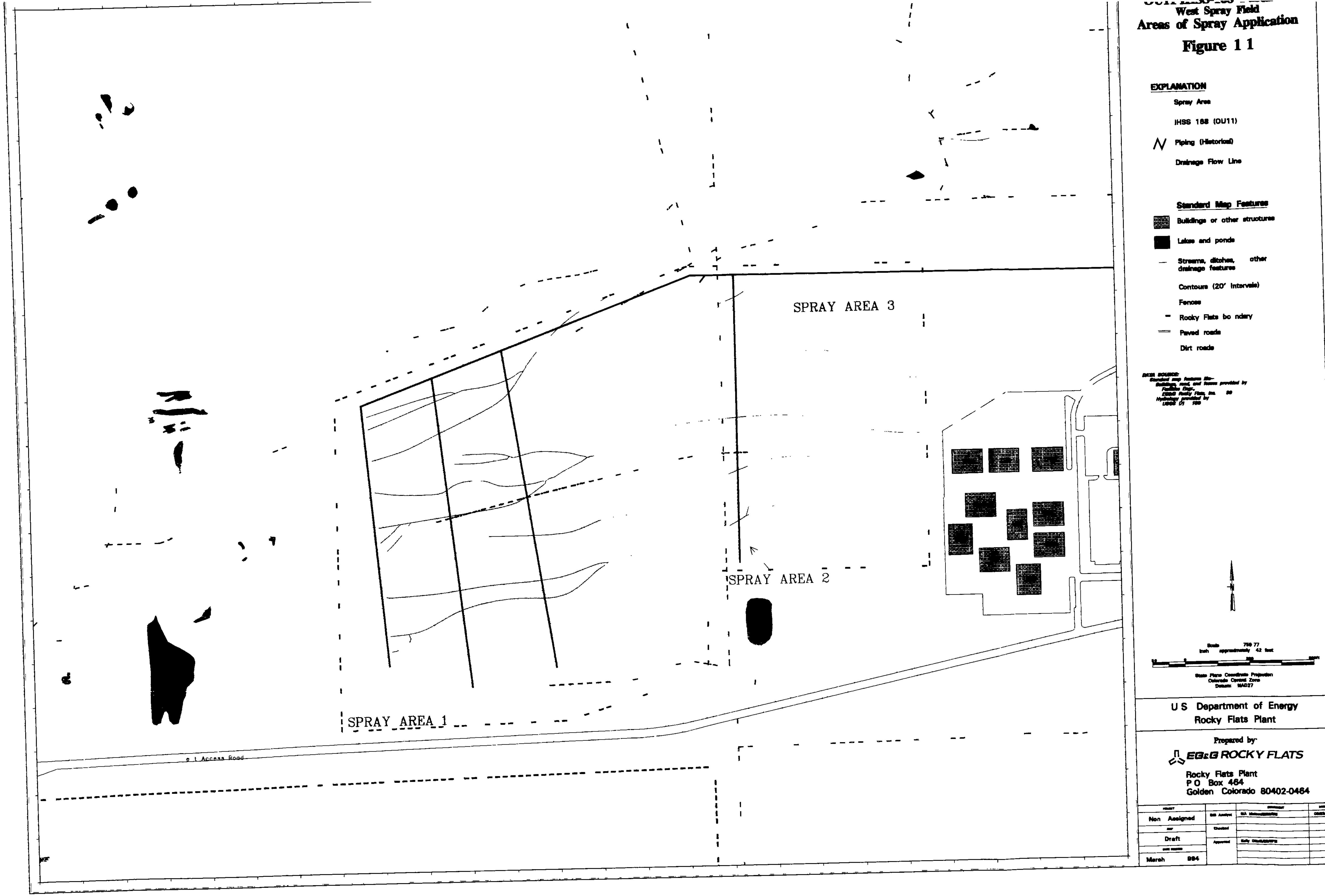
None Assigned		
raft	Checked	
M ch 994	Approved	Kelly


West Spray Field
Areas of Spray Application
Figure 1 1
EXPLANATION
Spray Area
IHSS 168 (OU11)
Piping (Historical)
Drainage Flow Line
Standard Map Features
Buildings or other structures
Lakes and ponds
Streams, ditches, other drainage features
Contours (20' Intervals)
Fences
Rocky Flats bo ndary
Paved roads
Dirt roads
SPRAY AREA 1
SPRAY AREA 2
SPRAY AREA 3
Access Road
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27
U S Department of Energy
Rocky Flats Plant
Prepared by
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Rocky Flats Plant
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Golden Colorado 80402-0464
Non Assigned
Draft
March 994